COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

March, 1949

Photo by Walter Fawcett

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VOLUME TWENTY NUMBER NINE

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FOR MARCH 1949

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Combustion is indexed regularly by Engineering Index, Inc.

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Published monthly by COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Ave., New York 16

A SUBSIDIARY OF COMBUSTION ENGINEERING-SUPERHEATER, INC.

Frederic A. Schaff, President; Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer

COMBUSTION is sent gratis to engineers in the U. S. A. in charge of steam plants from 500 rated boiler horsepower up and to consulting engineers in this field. To others the subscription rate, including postage, is $3 in the United States, $3.50 in Canada and Latin America and $4 in other countries. Single copies: 30 cents.

Issued the middle of the month of publication.

Publication office, 200 Madison Ave., New York CCA Member of the Controlled Circulation Audit, Inc.

Printed in U. S. A.

EDITORIAL

Financing Synthetic Fuel Plants

In his annual report to Congress on research and development progress of the U. S. Bureau of Mines, Secretary of Interior Krug advocates federal loans for the construction of pioneer commercial plants to produce oil and gasoline from coal and oil shale.

The Bureau and several private companies have already constructed pilot plants, as previously noted in these columns. While these have served to chart the way, it is now apparent that large-scale synthetic fuel plants will involve vast initial expenditures, too great perhaps to warrant private capital to undertake them unassisted, in view of the uncertain returns in competition with natural oil supplies.

Despite an unprecedented domestic output of oil, the current demand for petroleum and petroleum products is such as to make necessary large oil imports, and these are likely to increase. But too much dependence on foreign oil is generally regarded as a poor risk in view of unsettled world conditions. Therefore, since a question of national security is involved, it seems reasonable to expect the government to assist in the financing, as provided in two bills now pending in Congress.

Comparing Capabilities

The current trend toward employment of reheat for large high-pressure, high-temperature units in new utility plants has occasionally led to confusion when comparing them with units that conform to the "A.I.E.E.-A.S.M.E. Preferred Standards for Large Turbine-Generators." Obviously, full credit is given to the greater fuel economy of reheat, as well as certain other items; but confusion is likely to center around the greater capability of the so-called conventional machine over that of the preferred standard machine.

Under the Preferred Standards, which apply to straight-through condensing units, maximum generator capability is established at 10 per cent above nominal rating which, in turn, is based on a power factor of 85 per cent and a short-circuit ratio of 0.8. Moreover, such machines thus far are limited to maximum throttle conditions of 1250 psi, 950 F and a maximum size of 60,000 kw. On the other hand, the conventional reheat units are designed with a maximum capability of 25 per cent in excess of rating, a power factor of 80 per cent and a short-circuit ratio of 0.9; also higher steam conditions, as well as being built in larger sizes.

The excess capability of the conventional machine over that of the standard machine, when capitalized, will generally more than offset the extra initial cost of the reheat installation, leaving the fuel saving due to the reheat cycle as pure gain.

Last year nearly 50 per cent of all turbine-generators falling within the size range of the Preferred Standards were built in accordance with them; but the trend toward more widespread use of larger units, higher steam conditions and still wider adoption of reheat will likely reduce this percentage, at least on a capacity basis.

The point to be borne in mind is that capability must be taken into account when comparing conventional and standard turbine-generators.

To Better Small Plant Performance

To assist smaller industrial firms in obtaining information on their power plant performance, the British Ministry of Fuel and Power has evolved the design of a mobile testing unit equipped with a complete line of indicating and recording instruments mounted on portable panels and to be manned by a crew well trained in testing methods and interpreting readings. Presumably, if the results meet expectations, a number of such units will be built. There will be no charge for the service, the aim being a general improvement in British fuel economy.

It will be recalled that an extensive fuel conservation program was carried on among industrial plants in England during the later war years with considerable success reported, and a somewhat similar plan was initiated in this country early in 1944. Although different in set-up and scope, this latest effort of the British Ministry represents a peacetime approach to the same objective.

While lack of essential instruments is common among smaller plants both here and abroad, more often it is lack of proper maintenance and the consequent disuse of such instruments that account for poor performance and waste of fuel. Also, with changes in operating personnel, education in proper instrument use and interpretation of results are often neglected. Presumably the British plan is aimed at such corrective measures. Its success will be followed with interest and may also have application on this side of the Atlantic.

Fig. 1—S. D. Warren plant from the air

Coordination of Power and Steam at S. D. Warren Company

IN ITS ninety-five years of activity the S. D. Warren Company of Boston has encompassed a number of outstanding achievements in pulp and paper technology. At its Cumberland Mills plant near Portland, Maine, the first coated paper for printing was developed, while the initial American production of a true India paper took place in its Copsecook Mill at Gardiner, Maine. However, pioneering techniques have not been limited to paper manufacturing techniques, for the S. D. Warren Company was among the forerunners in proving the commercial possibilities and practicality of the transmission of electrical power from remote hydroelectric stations to a central manufacturing location. More recently it installed the first high-pressure steam generating unit operating on black liquor from the soda pulp process.

Historical development of the power and steam generating facilities is presented. Recent installation of a chemical recovery unit, modern steam generating equipment and back-pressure turbine-generators permits generation of power at a rate below that of 1942, notwithstanding sharply rising fuel costs. Power resources and methods of allocation of steam and hydro power are discussed.

Attention in this presentation is to be centered upon recent major improvements in the power and steam supply systems and to their coordination as an integrated element in paper production of the plant at Cumberland Mills. First, however, it may be well to look back and review some of the history and early developments of the company.

The site at Cumberland Mills on the Presumpscot River had been used for industrial purposes, principally concerned with lumbering and milling, for many years prior to 1854, when Samuel Dennis Warren purchased the financially faltering paper mill then located there. Readily available hydraulic power and an ample supply of suitable water for paper manufacture processing made the location extremely advantageous for the physical expansion of production facilities that was to follow. In the early days steam was generated in four isolated boiler plants, and numerous steam engines were installed to supplement power supplied from water wheels. Coal imported from Nova Scotia was burned in some of the boilers over a period of years, while in others anthracite coal and wood refuse provided the thermal energy.

By the late 1880's the time had arrived when the limited hydraulic power available at Cumberland Mills and the cumbersome operation of numerous steam engines made advisable the development of new sources of power for the expanding requirements of the paper mill. At this point Charles A. Stone and Edwin S. Webster, graduates of the Massachusetts Institute of Technology in the Class of 1888, who had formed a partnership as consultants in elec-

trical engineering, entered the picture of augmenting the power supply, as shown by the following excerpts from "The Story of Stone & Webster, 1888–1932":

"One of the first undertakings of Stone & Webster was the installation of a direct-current hydroelectric generation plant and transmission system for S. D. Warren Company, paper manufacturers. Although the power developed was only about 400 horsepower and the transmission distance slightly over a mile, this pioneering work proved the commercial possibility of the electrical transmission of power.

"Shortly after the first plant had been completed, the S. D. Warren Company ordered another plant. Research meanwhile had demonstrated the advantages and possibilities of alternating current and had developed apparatus which made its use commercially practical. The second installation, therefore, made use of alternating current and included an 8000-volt transmission line, one of the first 3-phase lines transmitting power at more than 2300 volts. It was also the first installation of the now famous Scott connection for transforming three-phase to two-phase and vice versa. These were the first installations for commercial purposes in New England and among the first in America."

About the turn of the century there were in operation four steam plants, of which three have since been abandoned. These contained a variety of steam generating and firing equipment.

The plant that is still in existence as a reserve steam supply at one time had sixteen boilers, of which four were Deane vertical fire tube units, six were 90-in. hrt designs, and six were Heine Type H long-drum, straight-tube boilers. With this steam generating equipment various methods of firing were employed, which embodied technical advances made during the intervening period. Underfeed stokers were the earliest used, and they were followed by chain- and traveling-grate and multiple-retort stokers. In two of the Heine boilers, water walls and screens were installed, enabling the use of pulverized fuel firing. The hrt boilers were set in batteries of two, and when six were changed to pulverized coal, the center walls were removed and the boilers raised, making a furnace 18 ft wide by 12 ft high and 24 ft long. Several different types of pulverizers were placed in service as they reached a state of commercial development.

In 1902 and 1903, three Westinghouse turbines of Parsons design and 400 kw capacity were purchased. One which included a separate coal-fired superheater bore serial number 50 and was among the early installations of such equipment for industrial plant power generation in this country.

As in all paper plants, power has been an element of major importance. Current plain and coated paper production averages 400 to 425 tons plus 175 tons of pulp per working day and requires approximately 15,500 kw of power and process steam supplied at 145, 36 and 10 psig. To provide this power and steam, exhaustive engineering studies were undertaken prior to World War II by the engineering staff under the direction of Killey E. Terry, then Chief Engineer and now Engineering Director, and Frank W. Roberts, now Chief Engineer. As a result of these efforts an expansion of steam and electric generating facilities was begun in 1941. Thus far, a C-E chemical recovery unit of 90,000 lb per hr steam capacity, operating on black liquor fuel from the soda pulp process, two Elliott back-pressure steam turbines aggregating 7000 kw, and two C-E Type VU steam generating units having a combined continuous capacity of 320,000 pounds of steam per hour have been placed in operation.

Before discussing the multiple power resources of the plant and their coordination, a general description of the newly installed power and steam facilities will be presented.

Fig. 2—24-hour paper mill operation permits this night view at new boiler plant

New Power Plant

The new power plant is composed of three buildings: one for the chemical recovery unit, another for the high-pressure, pulverized-coal-fired boilers and a third for the back-pressure turbines, boiler feed pumps and deaerating feedwater heater. The structures are located adjacent to one another, providing ready access to the various units and their auxiliaries. Fig. 2 shows an exterior view of the plant photographed at night.

The chemical recovery unit is designed to burn the organic matter from the black liquor obtained in the soda process and to recover the inorganic matter which is almost entirely sodium carbonate. Essentially the unit, a cross-section of which is shown in Fig. 3, consists of a four-drum boiler and cascade evaporator, with wide tube spacing provided to prevent bridging over by entrained solids in the flue gas. The steam generating capacity, when firing black liquor, is 90,000 lb per hr at 560 psig and 750 F leaving the superheater. Complete descriptions of the chemical recovery unit have been written by two members of the engineering staff of the S. D. Warren Company, R. E. Gilman[1] and Frank W. Roberts.[2]

As previously noted, there are two C-E Type VU steam generating units, a cross-section of one of which is shown in Fig. 4. These are designed to burn Pocahontas coals having the following physical properties:

Fixed carbon	72.7%
Volatile matter	19.0%
Moisture	3.0%
Ash	5.3%
Hardgrove grind	80
Btu per lb	14,300

Two Raymond bowl mills are supplied for each unit along with four Type R burners. Fig. 5 shows the installation of the pulverizers on the first floor of the plant, and Fig. 6 is a view of the firing floor to show the burners and a portion of the front of the steam generating unit.

[1] "Soda Black Liquor Generates Steam at New S. D. Warren Co. Plant," *Power Plant Engineering*, Jan. 1947, pp. 114–118.
[2] "Soda Recovery Boiler Gains By-Product Power and Steam," *Powerfax*, Elliott Company, Spring 1946.

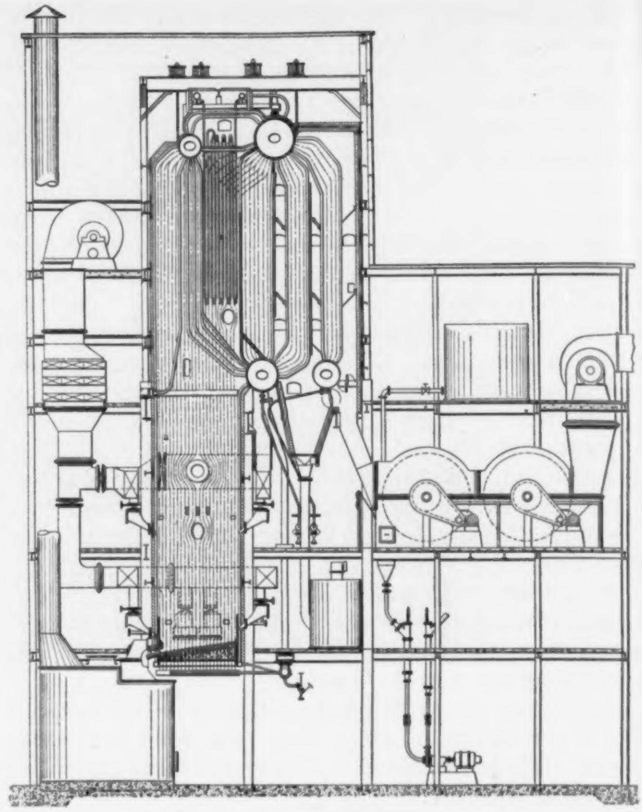

Fig. 3—Section through chemical recovery unit

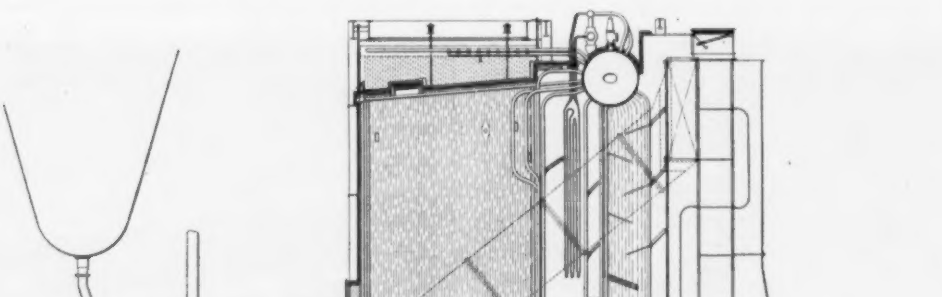

Fig. 4—Section through VU steam generating unit

The furnace has 4195 sq ft of heating surface and a gross volume of 13,000 cu ft. Plain tubes are used for the front, sides and rear of the furnace with finned tubes in the roof.

The boiler is designed for 600 psig and has 12,400 sq ft of heating surface. Additional heating surface of 3144 sq ft is contained in the superheater, while the tubular-type air heater includes 27,730 sq ft of heating surface.

Continuous rating for each steam generating unit is 160,000 lb per hr with superheater outlet conditions of 560 psig and 750 F and an overall efficiency of 87.0 per cent. The four-hour peak rating is 200,000 lb per hr.

evaporator and for process purposes. Some of the latter steam is further reduced to 10 psig for use in feedwater heating, low-pressure process requirements and plant heating. The exhaust from the 4000-kw machine is discharged at 145 psig into steam mains connected with the stand-by boiler plant and is distributed to supply the major process needs of the paper and pulp mill. Further reduction of pressure to 10 psig is also made, and there are several pressure-reducing and desuperheating stations to provide flexibility of steam system operation. These are shown more clearly in the schematic diagram of the steam and water connections, Fig. 8.

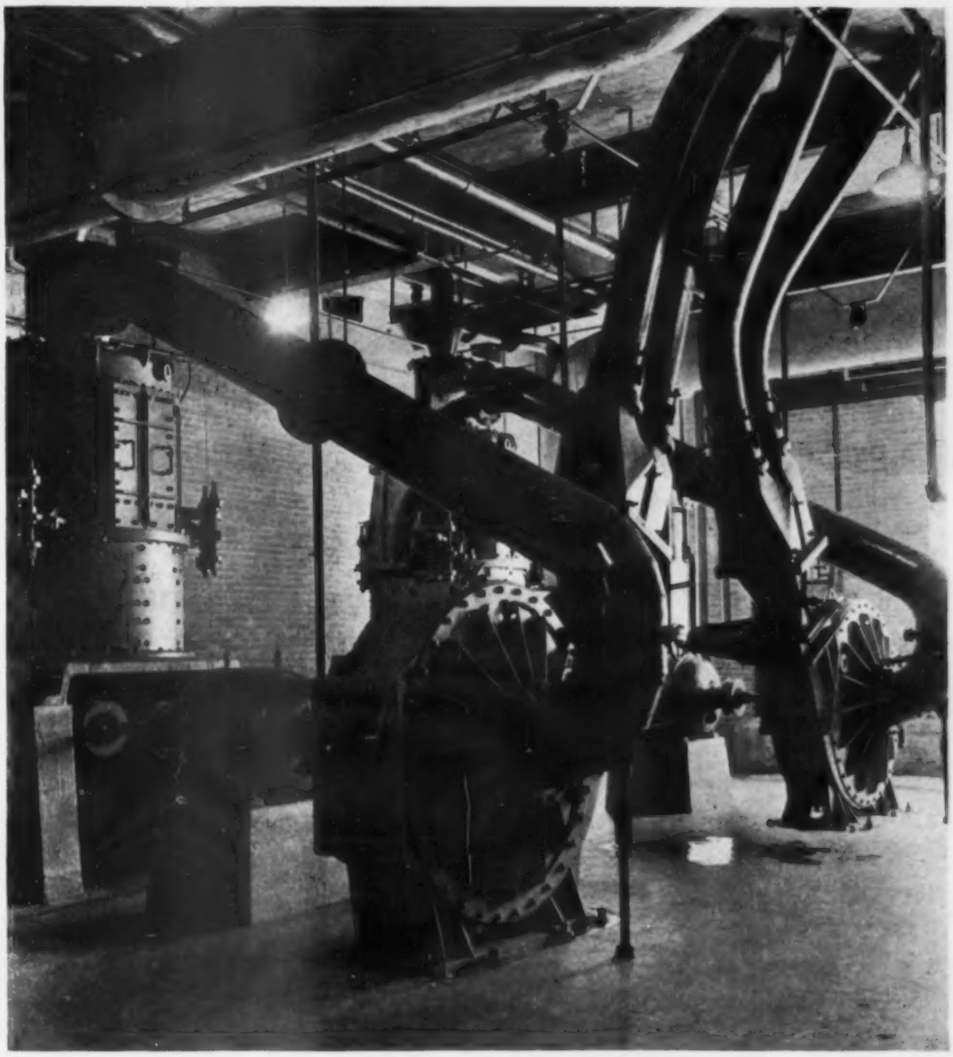

Fig. 5—Each of the boilers is served by two bowl mills

The turbine room building is a two-story structure designed for the ultimate installation of three turbine-generators which are intended to take care of future growth in mill power requirements. At present there are in operation two Elliott back-pressure turbine-generators, one of 3000 kw nominal rating and the other of 4000 kw nominal rating. Both receive steam at 560 psig and 725 F from a common header connected to the chemical recovery unit and the two Type VU steam generating units.

From the 3000-kw machine steam is exhausted at 36 psig and 325 F for use in the multiple-effect black liquor

Also located in the turbine building are four Ingersoll-Rand boiler feed pumps driven by Elliott turbines, as shown in Fig. 7. Two of the pumps have a capacity of 125,000 lb per hr, while the other two can each handle 500,000 lb per hr. A Cochrane deaerating feedwater heater is located in a room above the boiler feed pumps, and a closed heater is located in the basement.

The induced-draft fans have dual drives composed of synchronous two-phase motors and Terry turbines. Each of the two Buffalo Forge forced-draft fans driven by a squirrel cage motor has a rating of 56,000 cfm at 11.0 in. wg and 100 F, while each of the American

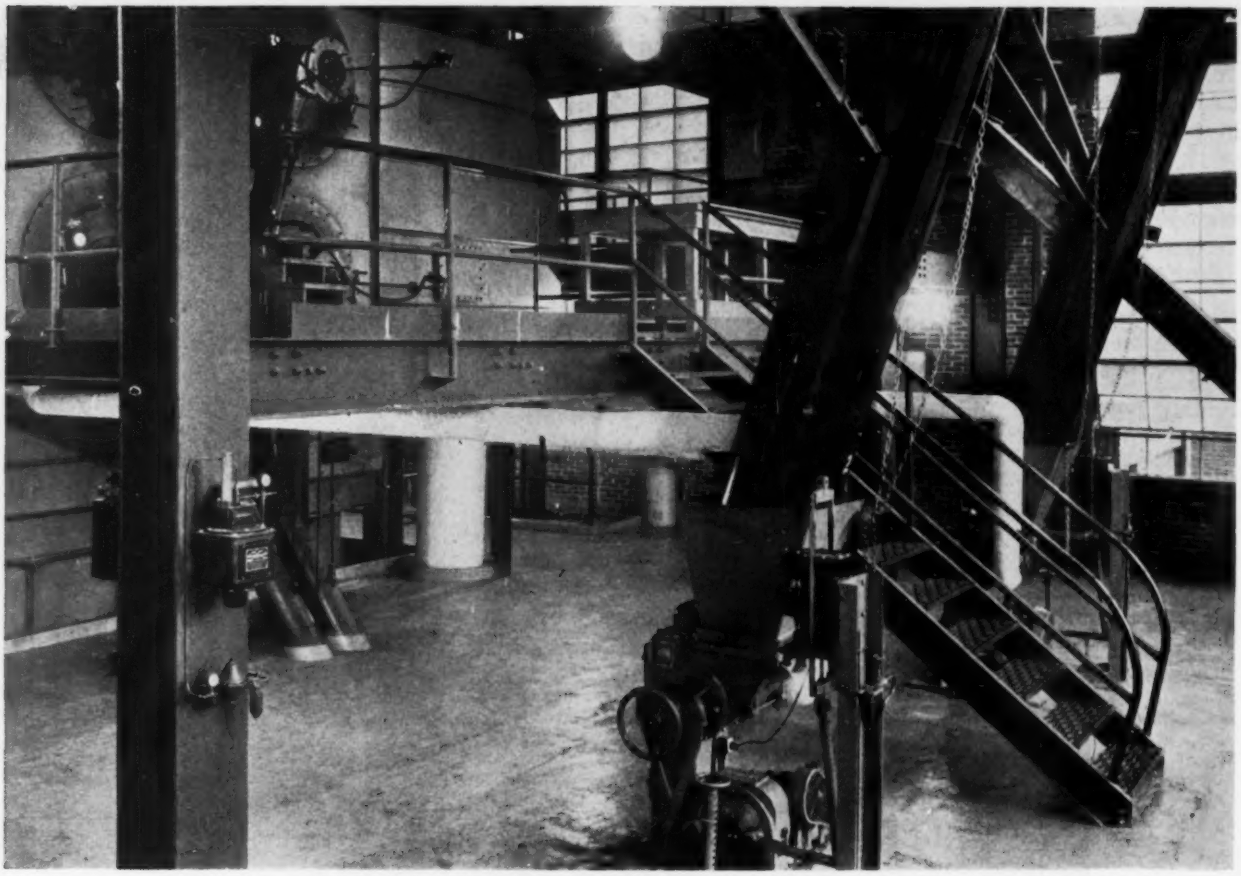

Fig. 6—View of firing floor

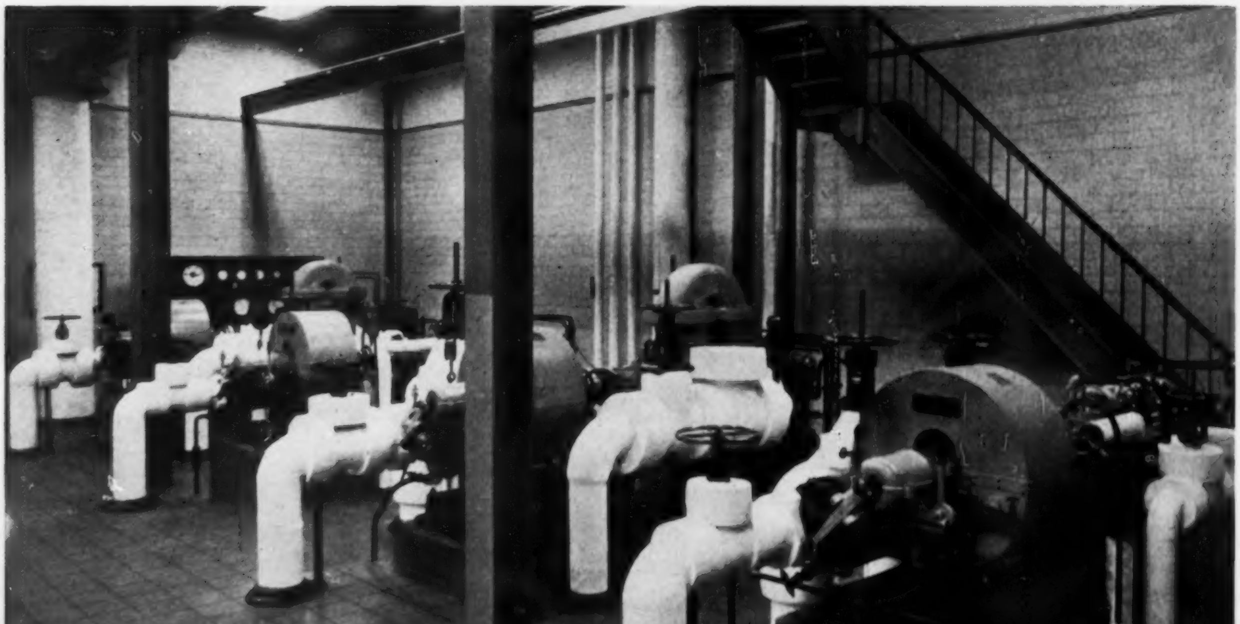

Fig. 7—View of boiler feed pumps

Blower induced-draft fans is rated at 96,000 cfm at 11.0 in. wg. Both forced- and induced-draft fans are controlled by inlet and outlet dampers.

Feedwater control is by means of Copes Flowmatic regulators, while combustion control, including the main panel operating board, was furnished by the Hagan Corporation of Pittsburgh, Pa. Feedwater treatment for the plant is provided by the Hall Laboratories. The pressure reducing valves and desuperheater stations were furnished by Swartwout, while the 600 psi valves for the high-pressure steam system are of Crane, Walworth and Edward manufacture.

Power Resources

Power derived from thermal energy is supplied from the back-pressure turbine-generators in the new turbine room previously described. There are also two condensing turbine generators aggregating 4500 kw available for use when system loads warrant or emergency conditions demand. Steam is likewise utilized to drive several steam engines for paper machines.

Hydroelectric power is furnished by three generating stations situated upstream on the Presumpscot River and one located at the Cumberland Mills plant. From the last-mentioned both electric power and direct-drive mechanical power are obtained. Table 1 summarizes the available power resources.

To visualize the utilization of the available power resources it is necessary to understand something of their relative costs. There are three types of purchased power obtainable, depending largely upon watershed conditions. In order of decreasing costs, these are steam-generated power, hydro power and dump hydro power.

TABLE 1—AVAILABLE POWER RESOURCES, KW

Hydro Stations	Head, Ft	20,000 Cfm Min Flow	35,000 Cfm Avg Flow	50,000 Cfm Max Flow
Eel Weir	41	600	1,225	1,800
Dundee	53	1,100	1,850	2,400
Saccarappa	28	500	1,000	1,400
Cumberland Mills	24	450	850	1,320
Total hydro power		2,650	4,925	6,920
Steam engines, paper machines		630	630	630
Non-condensing turbines		8,000	8,000	8,000
Condensing turbines		4,500	4,500	4,500
Purchased power		5,000	5,000	5,000
Total power, kw		20,780	23,055	25,050

For obvious reasons power in the first two categories is only purchased under conditions of absolute necessity, while advantage is taken whenever possible of available dump power.

Prior to the installation of the new steam and by-product power generation facilities, lack of water for hydro power coincided more often than not with similar conditions of the public utility, and under conditions of low water both systems were adversely affected. Now, however, the hydro system of the S. D. Warren Company may be more adequately and independently regulated to keep river flow as nearly constant as desired or to increase storage, within legally defined limits, for later use when required. Thus greater advantage may be taken of dump power when available and less dependence is placed upon watershed conditions, the result being a more flexible hydro-electric supply.

Power generated by the back-pressure turbine-generators is closely allied with plant requirements for process steam, and limits to the amount of power obtainable are set by production demands for steam. At times the combination of hydro and by-product power is insufficient to meet plant power requirements, and in these instances the condensing turbines may be utilized or power

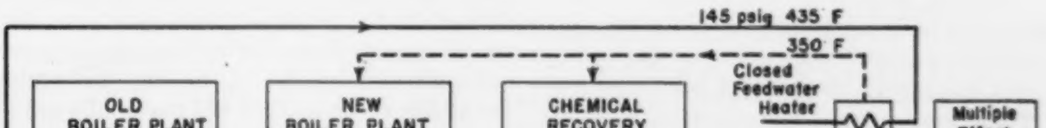

Fig. 8—Schematic diagram showing steam and feedwater systems

may be purchased. As mentioned previously, the choice depends, in part, upon relative costs. With dump hydro power available the condensing turbines would not be used.

Table 2 is taken from a study made in preparation for the design of the recent expansion of power facilities and illustrates distribution of power generation from several sources for conditions of a projected 15,500-kw load. Some idea of the interdependence of the various sources and their application to meet varying conditions can be obtained by analyzing Table 2 and Fig. 9 which shows consumption of power from the several sources for the years 1944 through 1948.

pressure turbine-generators to top the existing system has reduced the power cost per kilowatthour to an average of 49 per cent of its 1942 value.

Two points of particular interest in Fig. 10 show the effect on power and steam costs of the installation of the chemical recovery unit and the new boiler plant. In each instance there was an appreciable decrease in the cost of power and steam, notwithstanding the steady increase in fuel prices.

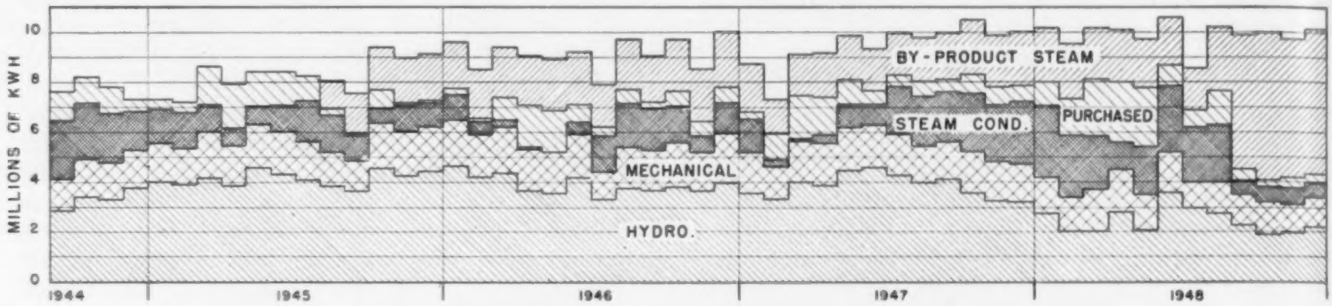

Fig. 9—Distribution of power production, 1944–1948

TABLE 2—DISTRIBUTION OF POWER RESOURCES TO MEET PROJECTED LOAD

	20,000 Cfm Min Flow	35,000 Cfm Avg Flow	50,000 Cfm Max Flow
Hydro stations	2,650	4,925	6,920
Steam engines	630	630	630
Non-condensing turbines	8,000	8,000	7,950
Condensing turbines	4,220	1,945	0
Purchased power	0	0	0
Total, kw	15,500	15,500	15,500

Fig. 9 illustrates on a monthly basis how the installation of the chemical recovery unit and the new steam generating units has affected the various sources of power. Generation by means of back-pressure turbines now accounts for 60 per cent of the total electric load, while purchased power and that generated by condensing turbines has been reduced to about 10 per cent.

Studies based on a 15,500-kw load and a river flow of 50,000 cfm with maximum hydro generation indicate a saving of $46.20 per hour for the new power development. Of the total load under these conditions, 6920 kw is derived from hydro sources, 630 kw from steam engines and 7950 kw from non-condensing, back-pressure turbines exhausting steam to process; these requirements can be met without purchase of power or operation of condensing turbines.

That those are not merely theoretical savings based on assumed ideal conditions can be seen from Fig. 10 in which index numbers for the cost of coal, steam and power are plotted for the years 1942 through 1948. With coal at 180 per cent of its 1942 value, steam costs have been limited to 102 per cent of the base figure, a result in large measure attributable to new and more efficient steam generating equipment operating at higher steam conditions. At the same time the use of back-

From the foregoing account some of the significant advantages of industrial power plant modernization may be observed. By replacing a low-pressure boiler plant with a high-pressure installation, including a modern chemical recovery unit and topping turbines, it has been possible to stabilize the operation of a combined hydro and steam system, to achieve greater reliability and dependability in meeting changing plant and water supply conditions, and despite increasing fuel costs to make a notable reduction of power costs while maintaining steam costs very close to their 1942 level. Sight has not been lost of the gains to be derived from a well-designed and efficiently operated power plant, and the S. D. Warren Company looks forward to its centennial in 1954, with the knowledge of having undertaken a power expansion program that will materially aid in continuing its leadership in the paper manufacturing industry.

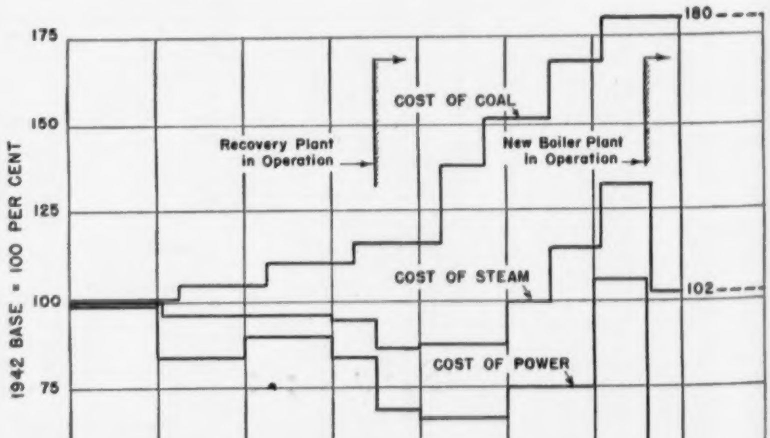

Fig. 10—Cost index curves, 1942–1948

Causes of Flue Gas Deposits and Corrosion in Modern Boiler Plants*

Experimental tests carried out in England to establish the occurrence of catalytic formation of sulfuric acid in boilers are described. Theories supporting the experimental evidence are discussed, along with methods of controlling and minimizing corrosion and flue gas deposits.

By W. F. Harlow

Chief Engineer, General Engineering Div., International Combustion Ltd., Derby, Eng.

IN A previous paper by the author[1] it was established that sulfur trioxide, responsible for the deposits and corrosion in air heaters and economizers, was produced in flue gases during their passage over the heating surfaces of the boiler, particularly the superheater, by the process of "surface catalysis." This finding was based on the fact that heated iron in contact with flue gases will generate sulfur trioxide at its surface to an extent depending on the surface and temperature conditions. Further experience indicates that in addition to producing sulfur trioxide in flue gases leading to economizer and air heater deposits, catalytic action is responsible for the formation of deposits on the boiler surfaces at which the process occurs.

Experimental Evidence

In the tests upon which this paper is based flue gases were obtained from a small cast-iron sectional header boiler fired by an automatic underfeed stoker. The gases were led from the uptake by a 1-in. pipe to a mild steel 3-in. diameter tube of 7 ft length. In this tube were arranged 30 short sections of 2-in. superheater tubing each $1^1/_2$ in. long as shown in Fig. 1. The tube and contents were arranged to be externally heated at one end by gas burners and cooled at the other extremity by water sprays in order to obtain a gradation in temperature along the tube comparable to that of the metal temperature existing in a boiler plant from superheater to air heater. The tube was well rusted internally, but the specimens and supporting plates were sandblasted before each test.

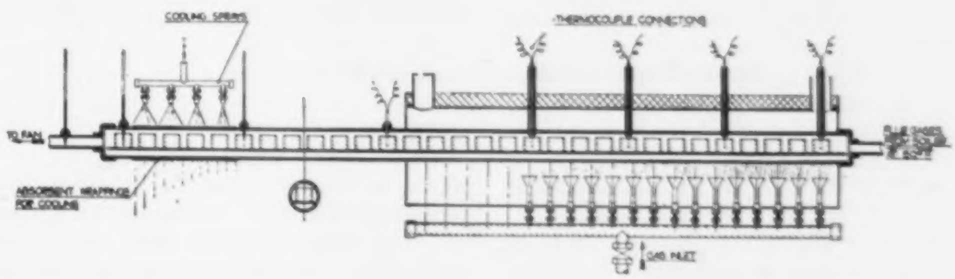

Fig. 1—Apparatus for demonstrating formation of low-temperature deposits by high-temperature surfaces

Gases were drawn through the tube by a fan, the time taken by the gases to pass over the specimens being similar to that for flue gases to pass from superheater to air heater in a modern boiler. The coal used had a sulfur content of 0.8 per cent, and rock sulfur ground to 200 mesh was added to raise this content to 3 per cent.

Two series of specimens were first tested for a total period of 169 hours each under two sets of temperature conditions. In one case, series "A," the specimens were raised to a maximum temperature of 1060 F, which is approximately equal to superheater metal temperatures for steam at 950 F, and cooled to a temperature of about 185 F, which approximates the metal temperature prevailing in many air heaters. In other cases, series "B," the maximum temperature was 740 F and the terminal temperature was substantially the same as in the first test.

With series "A" condensate appeared on the cooler specimens, the number of those which were wetted and the amount of condensate formed both increasing as the

* Abridgment of a paper given before the Institution of Mechanical Engineers, London, Eng., March 4, 1949.

[1] "Causes of High Dew Point Temperature in Boiler Flue Gases," *Proceedings of the Institute of Mechanical Engineers*, **151** 293 (1944).

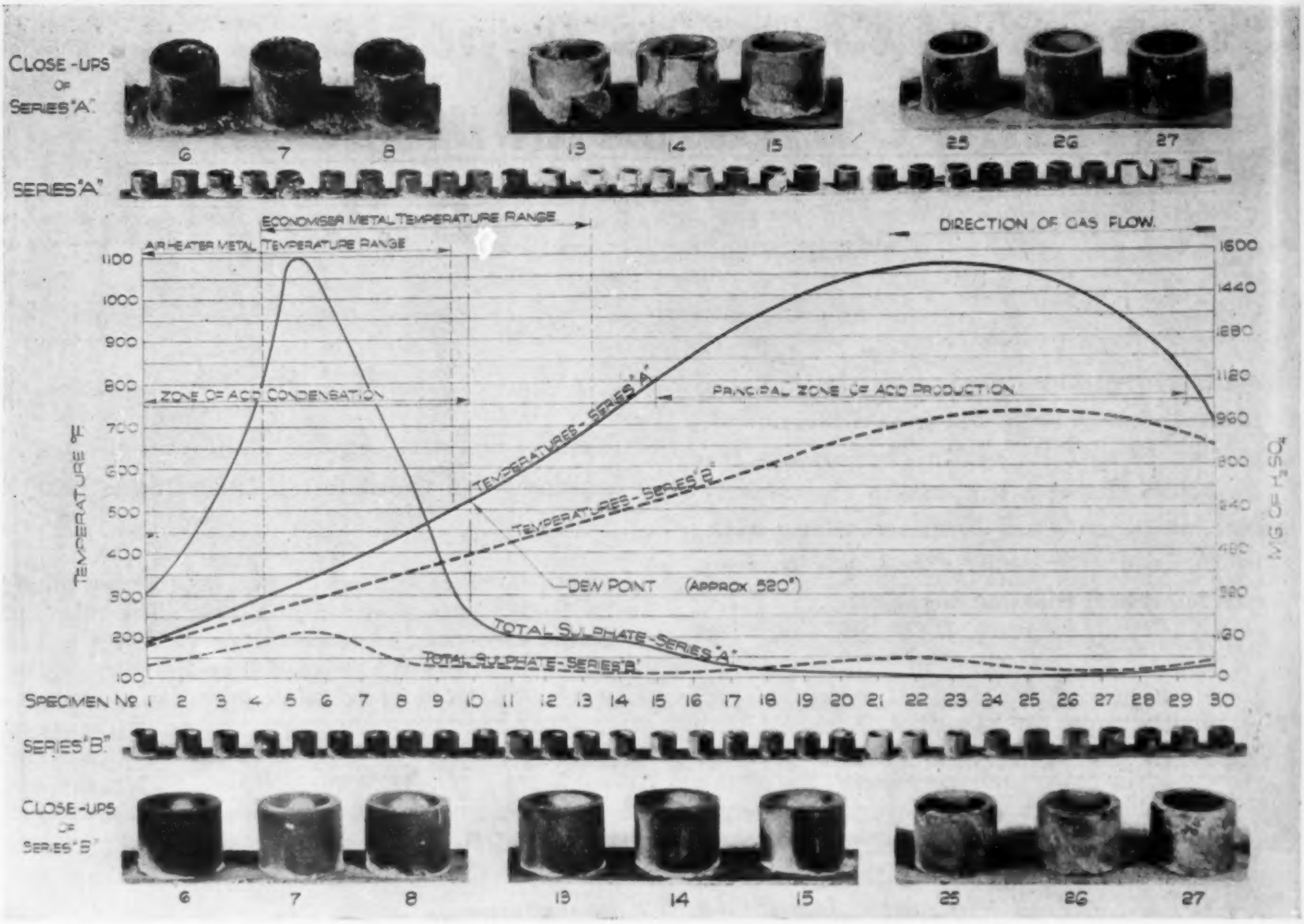

Fig. 2—Effect of flue gases on heated iron surfaces

tests proceeded; with series "B" all the specimens remained dry.

The results are shown in Fig. 2, the photographs being taken seven days after removal in each case. It will be seen that in series "A" the last ten specimens have received considerable deposits whereas with series "B" no deposits are apparent. The specimens in the high-temperature zone from about 900 F upwards were covered by a brownish-red "bloom" changing to black; this surface afterwards flaked off, the scales being magnetic.

In order to obtain gravimetric as well as visual results, two further sets of specimens were heated to the same gradations in temperature but exposed to the gases for a shorter period of 100 hours, so that less condensate would be formed and therefore retained on the specimens. The total amount of sulfuric acid in the free and combined state on each specimen was then estimated by chemical means as shown in Fig. 2. It will be noted that sulfate formation becomes important at about 520 F which coincides with the point where wetness was observed to commence and therefore can be considered to be the dewpoint.

Since no sulfuric acid was observed in series "B," it could not have been produced in the furnace but must have been formed in the gases during their passage over the surfaces. It follows that a similar effect must be produced where the temperature and surface conditions are comparable.

Experiments were also carried out with two series of specimens simultaneously exposed to flue gases in twin channels made of steel plate (Fig. 3) and maintained at a temperature gradation similar to series "A." In one channel the specimens in the zone above 800 F were omitted, resulting in a lowering of the dewpoint temperature so that deposits commenced to form later, thus

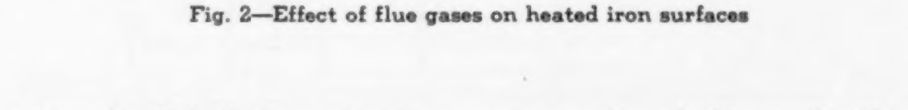

Fig. 3—Effect of extent of high-temperature surface area on low-temperature deposits

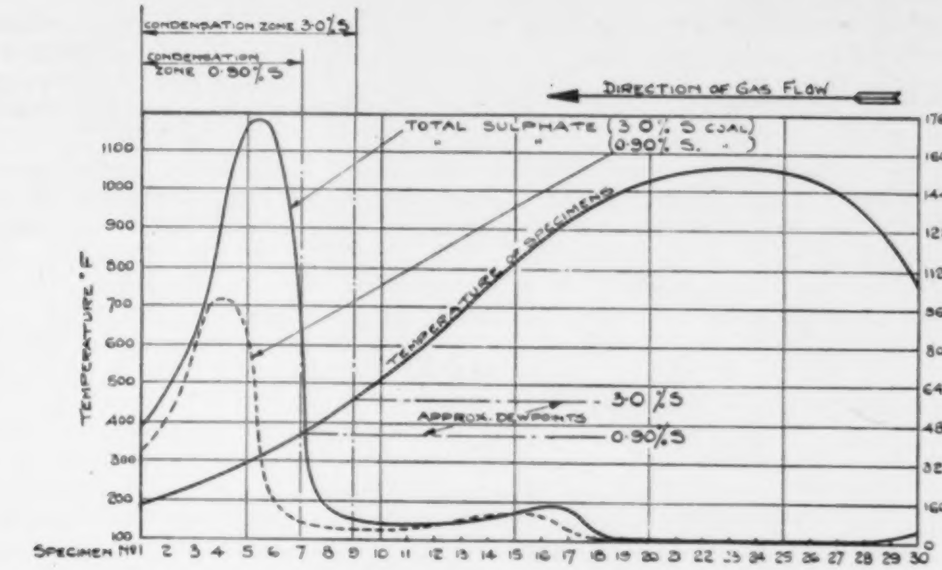

Fig. 4—Effect of sulfur content of coal on deposit formation

showing that acid production depends upon the extent of surface exposed as well as its temperature.

Tests were made to determine the effect of fuel sulfur content, and it was observed that even with comparatively low sulfur coal the acid condensation still occurs (Fig. 4). As might be expected, the amount of acid deposited and the dewpoint temperature both increase with sulfur content.

Condensate Tests

To ascertain the precise nature of condensate obtained at various temperatures, flue gases were passed through a steel tube filled with steel scrap heated to 1000 F and then cooled in a Liebig condenser. Two methods of condensation were employed, one utilizing two stages and the other a single stage. Table 1 indicates the analyses of the samples.

It should be noted that condensate obtained at 140 F and 60 F contained hydrochloric as well as sulfuric acid, a factor which has significance in understanding the resistance of metals to flue gas corrosion.

TABLE 1—ACID CONCENTRATION IN CONDENSATES FROM FLUE GASES

	Condensation in Two Stages		Condensation in One Stage
	200 F	60 F	140 F
Sulfuric acid, per cent H_2SO_4 (total)	59.66	1.07	4.69
Sulfuric acid, per cent H_2SO_4 (free)	57.92	..	2.49
Hydrochloric acid, per cent HCl (total)	Trace	0.79	0.81
Phosphoric acid, H_3PO_4	Trace	..	..

Surface Catalysis

Though its effect was discovered by Humphrey Davy in 1817, the mechanism of catalysis is not as yet fully understood. Many substances have been discovered which have the property of accelerating chemical reactions, and in the formation of sulfuric acid some are active at low temperatures while others exhibit the property only at elevated temperatures. Ferric oxide has its maximum activity at about 1100 F, a temperature at which its transfer to magnetic oxide, Fe_3O_4, begins (Fig. 5). The release of oxygen brought about by this conversion may possibly explain the ability of this material to effect the catalytic oxidation under discussion.

Contamination of catalyst substances reduces this activity and is termed catalyst poisoning. Dust in gases is the most frequent cause of such poisoning. There may

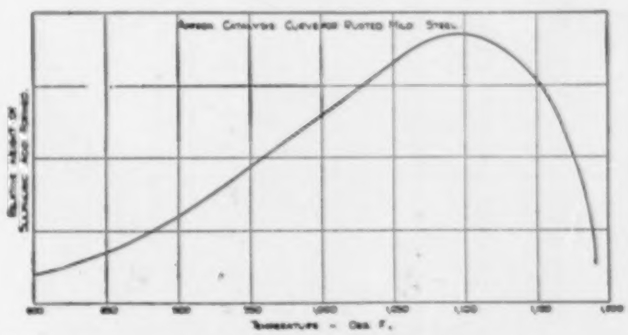

Fig. 5—Curve showing variation of catalytic activity of iron with temperature

also be a chemical reaction involving the catalyst that will reduce its activity. Ferric oxide may be reacted upon by the sulfur trioxide formed by the catalytic reaction to form ferric sulfate. The extent to which this occurs is affected both by the temperature and the partial pressure of the sulfur dioxide in the gases.

With the normal low concentration of sulfur dioxide in the flue gases, no sulfate can be expected to form at catalyst temperatures above 900 F. It does, however, occur in boilers with surfaces below this temperature. When boiler heating surfaces are exposed to dust-laden gases, reactions of sulfur trioxide with the various solid contents of the gas stream may occur, and alkali metal compounds, including sulfates, may deposit on tube

surfaces. The compounds formed will depend upon the surface temperatures at the various locations (Fig. 6).

While the normal surface temperature of tubes is too low for the highest catalytic activity of ferric oxide or other substances that possess this property, it is proposed that the catalysis of combustible gases and oxygen at surfaces may increase the surface temperature so that significant amounts of sulfur trioxide may be formed. The growth of deposits on furnace and boiler tubes is taken as evidence that the surface temperature of these tubes is higher than the expected temperature based on the rate of heat transfer and the tube wall thickness.

Primary and Contributory Causes of Deposits

It is contended that the primary cause of the flue gas deposits in all parts of modern boilers is the production of sulfur trioxide by surface catalysis brought about by the temperature and condition of the heating surfaces of the boiler and/or superheater. In other words, these deposits arise from the production of gaseous sulfuric acid on the hotter surfaces and its condensation on the cooler surfaces. There is a zone of generation which may include superheater, first bank and furnace tubes and a zone of condensation which may include the economizer, air heater and sometimes the last bank of boiler tubes.

Fig. 6—Air heater with elements cut away to show perforations caused by flue gas corrosion

There are also contributing factors which have an influence on deposit formation and must be considered. The following conditions are necessary for boiler heating surface to become catalytic:

1. The surface must be at the necessary temperature.
2. The surface must have a coating of ferric oxide (or a product containing this).
3. The coating must be in an active condition.

The temperature of the surface, although governed mainly by that of the contained fluids, is often unduly elevated by the unconsumed gases burning at the tube surface. Whether this will occur depends on flame length in relation to furnace dimensions.

The factors which determine the formation of ferric oxide are not clear, but some boilers will operate for one or two years before trouble occurs, while others will encounter difficulty almost immediately after going into service. This may be due to the protective coating of black magnetic oxide, Fe_3O_4, which is acquired in the tube manufacturing process. Also the physical composition of the steel may have some bearing on the matter.

Iron oxide catalysis can be greatly hindered and even rendered inoperative by dust, soot and certain other materials which apparently obstruct the diffusion of the reacting gases to the catalyst surface. Pulverized fuel dust is markedly effective in this respect, and it is probable that stoker-fire dust exerts a similar though reduced effect. With oil firing, the lack of comparable dust may be a partial explanation of the greater difficulties with acid formation in such plants.

Although there are many contributing factors which may influence deposit formation, these can have no effect if any of the three conditions previously mentioned as necessary for catalysis is unsatisfied. If the temperature of the tube and the covering scale is restricted to a degree where action cannot readily take place, the deposits will be negligible regardless of the fuel and other factors. If there is no ferric oxide scale on the tubes, or if this material is in any manner rendered inoperative by poisoning, there can be no catalysis.

Further Experimental Results

Additional tests were carried out to reach the following experimentally determined conclusions:

1. A rusted surface is exceptionally active, whereas a clean or black oxidized surface is without effect until corrosion occurs.
2. Small quantities of lime and soda have a temporary inhibiting effect. The protection is greater if applied to an initially cleaned surface (Fig. 7).
3. New boiler tubes, unless rusted, do not exhibit any appreciable catalytic activity.
4. The compact black oxide coating which some tubes receive in the course of manufacture appears to be highly protective and endures for some time, but black oxidizing which is carried out merely by heating has only a very temporary effect.
5. It does not appear possible to avoid the catalytic effect of boiler surfaces by the use of alloy steels.

Alternative Theories

The formation of sulfur trioxide in furnaces is not completely understood, one theory being that it is due to reactions which take place in the combustion process. In the manufacture of sulfuric acid chemical engineers have studied the production of acid very closely and have concluded that the action of the surface of the containing vessel is an important factor in acid formation. Yet there is some experimental evidence to indicate that small amounts of sulfur trioxide are formed during combustion, particularly in flames from illuminating gas.

In the case of modern water-tube-boiler furnaces where the temperature is of the order of 2500 F, no reliable evidence of more than a trace of sulfur trioxide in the combustion zone has been found by the author. Even in this instance it is thought that the substance may have been produced in the sampling process. At the walls of the furnace, however, the presence of larger quantities of sulfur trioxide has sometimes been detected.

Fig. 7—Effect of treated surface on superheater deposit formation

Both experimental and operating evidence seem to minimize the possibility of the theory of acid formation, by means of the combustion process, being correct. Since boiler tube cleaning can be shown to have a definite effect upon tube corrosive deposits, it is difficult to understand how the theory can explain the influence of the combustion process on deposit formation. Similarly, operators are familiar with a period of deposit-free conditions for a year or more following initial firing which cannot be explained in terms of the reactions of the combustion process.

Another theory quite commonly held is that deposits on the tubes are thrown up as such from the fuel bed, particularly from the rear end of the grate. Like the combustion process theory just mentioned, this explanation cannot justify the immunity to corrosion of washed tubes and new boiler surfaces.

Conclusion

Two alternatives appear to exist in removing the cause of flue gas deposits and corrosion:

1. The temperature of the boiler heating surfaces must be limited so that no considerable catalysis occurs.

2. Means must be found to prevent or substantially reduce the catalytic effect, regardless of the surface temperatures acquired.

In view of the need and desire to gain the economies resulting from the operation of the Rankine cycle at high temperatures and pressures, there is little opportunity for taking advantage of the first alternative. Good design with respect to arrangement of heating surfaces and control of combustion processes can be of limited influence.

More encouraging possibilities are included in the second alternative. Surfaces may be immunized to a greater or lesser degree, and it may be possible to find a solution which will render them permanently and entirely non-catalytic. Even if this ideal condition does not develop, some practical process of periodic treatment may be found which can be applied economically. A further possibility is to apply treatment continuously by introducing necessary material with the fuel, an example of which is the effect of pulverized fuel ash in inhibiting catalytic activity of rusted mild steel.

It has been suggested that a reduction in the quantity of this fine ash will correspondingly decrease the deposit formation, but there is much evidence to show that such material actually reduces the deposits. In fact, in boilers fired by oil having almost no ash content, very heavy deposits are formed. Therefore, at the present time pulverized fuel appears to be the best established answer to the problem, as shown by the limited extent of trouble with these plants, both in Great Britain and in America.

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Fig. 11365—Class 1500-pound Cast Steel Horizontal Lift Check Valve with welding ends. Pressure Sealed Cap and piston-guided disc. Streamline design permits maximum flow through the valve with minimum pressure drop. →

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Fig. 1793—125-pound Iron Body Bronze Mounted Gate Valve with outside screw rising stem, bolted flanged yoke and tapered solid wedge.

Fig. 11331-Y—Class 1500-pound, new Powell design, Cast Steel "Y" Valve with welding ends and Pressure Sealed Bonnet. This design permits almost unobstructed flow through the valve body, practically eliminating all pressure drop and turbulence.

Fig. 11303—Class 1500-pound Cast Steel Gate Valve with welding ends and new patented Pressure Sealed Bonnet.

Fig. 19031—Class 900-pound Cast Steel, Streamlined Pattern, Globe Valve with welding ends and patented Pressure Sealed Bonnet. This improved design reduces pressure drop and turbulence to the minimum. Spur gear operation (shown with gear cover removed).

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POWELL VALVES

Steam Peaks in Industrial Plants

Abstract of a paper by Dr. E. G. Ritchie* before the Institute of Fuel, London, England, on January 25, 1949, in which are discussed problems due to fluctuating process steam demands in various types of industrial plants. The author indicates how the effects of such conditions may be lessened or eliminated.

WHERE the stream demand fluctuates widely it is very difficult, with solid fuel firing, to maintain a uniform fuel bed or a proper distribution of the combustion; hence a large excess of air finds its way into the combustion chamber, diluting the products of combustion, adding to combustible in the solid residue, and lowering the efficiency.

In many cases a sudden increase in steam demand is followed by a reduction of steam pressure in one department or another, depending upon the extent to which pressure regulation is employed, particularly where steam mains are inadequate to meet the peaks because of factory extensions that have been made without regard to the steam-carrying capacity of the piping.

In some processes the rate of output, as measured by the rate of heat transfer, is dependent not only on temperature difference but also upon pressure head in the steam main, as, for example, where water or liquor in a tank is heated by an open coil. In such cases a drop in pressure at the consuming vessel, due to development of a peak, reduces both the temperature and the pressure potential and the process is slowed down. Obviously, the actual effect of steam-pressure variation on the performance of the consuming equipment depends on the nature of the process.

In sugar refining a critical part of the process is the crystallization of the sugar from the mother liquor in the vacuum pans. Concentration of the liquor is carried out by indirect heat transfer, using steam at a comparatively low pressure. At a certain stage the crystals begin to form and, as they grow, constant check must be kept on their size. At the precise moment when the correct grain size has been developed, the pan is "dropped" and the sugar removed from the mother liquor by centrifuging. Should the steam pressure increase when crystallization is nearing completion, the temperature of the mother liquor would rise and the sugar go back into solution. This would necessitate continuation of the process under increasingly critical conditions, as the liquor becomes more and more concentrated. On the other hand, if the steam pressure drops there would be considerable risk of the sugar crystals growing too rapidly, more water would have to be added, the sugar remelted, and the whole process of evaporation and crystallization repeated. This would delay production and increase the heat consumption per unit of output.

In a brewery, sterilization of the beer is a most important consideration. It is usually carried out with steam at low pressure, and therefore small variations in steam pressure may actually stop the sterilization, unknown to the operators.

In a dyeworks, color development is concerned with maintenance of constant steam pressure, and there are many ways in which fluctuations in steam demand can play havoc with the process.

In the steel industry steam pressure can be upsetting where the rolls are engine-driven. Many more examples could be cited.

The overall effect of a fluctuating steam demand on the rate of output and the fuel consumption per unit of output is difficult to determine with any degree of accuracy, but observations by the author following installation of thermal storage equipment in a number of industrial plants serve to indicate what happens when the peaks and valleys are suppressed and the steam pressure brought under control.

In a steelworks where a steam accumulator was installed the increase in output due to the elimination of peaks was of the order of 20 per cent, while the saving in gas due to the speeding up of production was approximately 30 per cent. In another such plant the saving in safety-valve loss, due to installation of an accumulator, was found to exceed 15 per cent of the steam generated.

In a sugar refinery the increase in output of refined sugar, due to suppression of peaks, was around 12 per cent while the fuel consumption per ton of product was reduced by 7 per cent. In one brewery the reduction in fuel consumption amounted to 16 per cent, and in another, 10 per cent. Similarly, a large dairy increased its output over 20 per cent and the fuel consumption per unit of output about 10 per cent.

Causes of Fluctuating Demand

The principal cause of a fluctuating steam demand in an industrial plant is the starting and stopping of large individual steam-consuming equipment, or the simultaneous starting and stopping of groups of smaller steam process equipment. A contributory factor is that some such consumers require steam at a high rate when started and the demand falls off appreciably as the process proceeds. This condition applies particularly to vulcanizers, certain evaporators, bulk sterilizers and in various processes associated with the dyeing of fabrics. Also, a short peak is sometimes caused by filling and heating up of a cold steam line or when process equipment is started from a cold condition.

Furthermore, there is a considerable time lag due to the thermal inertia of the water content of the boiler, and this must be overcome before evaporation can be

* Director of Engineering Laboratories, British Coal Utilization Research Association.

increased to meet the increase in steam demand. From this point of view the shell-type boiler takes longer than the water-tube type to react to a change in firing rate because of its large water capacity, but the resultant loss in steam pressure is less owing to its greater inherent thermal-storage capacity.

When several such consumers are brought into operation more or less simultaneously the steam demand may rise above the boiler capacity available.

In addition to the foregoing, there are some processes where seasonal conditions complicate the problem. For example, in a woolen mill the summer weight of material may be manufactured in the early spring and the winter grade in the late summer or autumn, and the difference in steam demand may be appreciable. A winter-heating load will add to the steam demand, but it is normally steady.

In considering peaks and valleys in steam demand an important factor is that false peaks may be created as a result of the increase in steam consumption due to a drop in boiler pressure. This applies particularly where a large part of the steam is required for power generation.

From the standpoint of diversity, the concentration of small industrial plants in a given area and supplying them with steam and power from a central source is a trend that makes for increased efficiency.

One method of suppressing peaks and valleys is to schedule, where possible, manufacturing operations so that intermittent large steam consumers do not clash; that is, to avoid their simultaneous starting up. For example, to allow dyers in a textile finishing plant to scramble for steam first thing in the morning and after the mid-day break is illogical if it is found to result in general loss of output.

Automatic combustion control is only a partial solution, as the combined peaks are generally in excess of the overload capacity of the boiler plant, while the rate at which they develop and fall off, in relation to the inertia of the fuel bed and that of the water contained in the boiler, is usually such as to put them beyond the reach of such control.

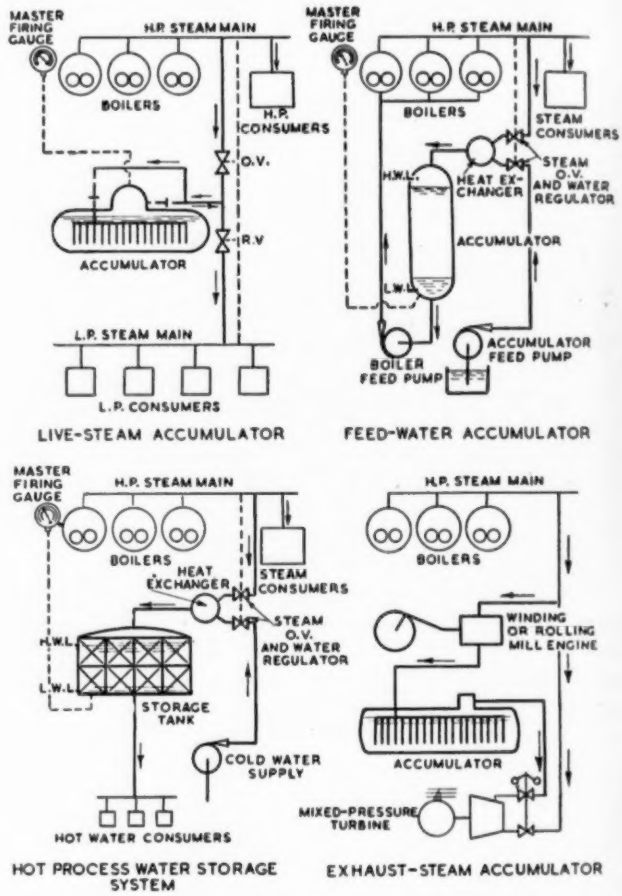
Thermal Storage

Installation of thermal storage is a satisfactory method of suppressing peaks and valleys in that it provides a "flywheel effect" for the boiler plant. This may be in the form of a live-steam accumulator, a feedwater accumulator, hot-process-water storage or exhaust steam storage.

The live-steam accumulator operates over a wide range in pressure, generally from full boiler pressure to that at which the low-pressure process equipment is supplied. Surplus steam generated is stored under a rising pressure in the accumulator and regenerated as steam under a falling pressure. Charging and discharging are automatically controlled to maintain the boiler and process pressures constant.

The feedwater accumulator operates at a constant pressure equal to the boiler pressure and provides a means whereby surplus steam is used to "top up" the feedwater to saturation temperature. Charging and discharging are by rise and fall of water level in the accumulator. This system is practicable only where the feed temperature to the boilers is relatively low; hence it is generally inapplicable where economizers are employed. It is sometimes used in steel plants.

In many industries large quantities of cold water have to be raised to near boiling point at atmospheric pressure. If this is done with surplus steam, and sufficient tank capacity is provided to meet the peak conditions,



Four types of steam and hot-water accumulators

by rise and fall of water level, excellent flywheel effect is obtained. This hot-process-water storage system is expecially useful in breweries, dyeworks, laundries, tanneries and dairies. It has the merit of low cost; and, apart from its use as a means of controlling steam pressure, it helps to increase the rate of output by eliminating the time required for boiling.

With the exhaust-steam storage system exhaust from a prime mover, such as a winding or rolling-mill engine, is stored intermittently and regenerated at a more or less steady rate to meet the needs of a mixed-pressure turbine. The accumulator thereby levels out the peaks and valleys between the main consuming equipment and the power house, besides conserving exhaust steam and avoiding the intermittent transfer of power load to the boiler plant. The principle of action is the same as in the live-steam accumulator, except that mechanical control of the charging and discharge processes is not employed. The pressure range in an exhaust-steam accumulator is usually from 5 psig to atmosphere. Use of the system is confined largely to steel mills and collieries.

The accompanying diagrams represent these four types of steam and hot-water accumulators. Commenting on these types, the author claimed for the live-steam accu-

mulator the advantage that it provides practically a complete solution to the problem, the maximum demand that it can handle being determined only by the maximum permissible rate of steam release from the free water surface, which is high. The hot-process-water storage system has the merit of simplicity and cheapness. A combination of the two systems, when practicable, represents a most satisfactory solution, especially in a combined power and heating system. In that case, the hot-water accumulator, using exhaust steam, would take care of the major part of the out-of-balance heat demand, and the steam accumulator would handle the shorter and sharper parts of the peaks.

Facts and Figures

Heat pumps employing turbo-compressors generally use methyl chloride or freon as a working medium.

•

The conductivity of scale increases with its density, and silica scale offers the greatest resistance to heat transfer.

•

According to Anthracite Institute, the 1948 production of anthracite approximated that of 1947, namely, around 54 million net tons.

•

In 1947, 244,000 fewer miners produced 51,000,000 more tons of coal than in 1920, according to Bituminous Coal Institute.

•

A boosting of hydrogen pressure from 15 psig to 30 psig for large electric generators is reported as under consideration to permit an additional 10 per cent capacity.

•

High-volatile coals do not require as fine pulverization as low-volatile coals because they ignite more readily. On the other hand, low-volatile coals (excepting anthracite) have higher grindability because they are softer.

•

Mathematical determination of stresses in piping systems involves the solution of six simultaneous equations for two points of fixation, with an additional six equations required for each subsequent point of fixation.

•

The new Cunard White Star liner *Caronia* which recently arrived in New York, completing her maiden trans-Atlantic voyage, is equipped with six five-drum Yarrow-type boilers which deliver steam at 600 psig, 800 F. Four of these are rated at 86,000 lb per hr and two at 50,000 lb per hr.

•

Since elevation above sea level affects density of the air, this must be taken into consideration when figuring the capacity of a fan.

•

The sequence of starting a direct-fired pulverized coal installation is first the induced-draft fan, then in order, the forced-draft fan, the pulverizer exhauster, the mill, and the feeder.

•

Since hydrogen is released when hydrochloric acid reacts with iron, it is important that proper precautions be taken to avoid explosion when chemically cleaning a boiler.

•

A 5000-kw open-cycle gas turbine now nearing completion for 1500-F operation is expected to produce a kilowatthour on 0.7 lb. of heavy fuel oil.

EXPLOSION DOORS FOR BOILER FURNACES

By JOHN VAN BRUNT

Consultant Engineer, Combustion Engineering-Superheater Co., Inc.

A talk before the Boiler and Machinery Division of the National Bureau of Casualty Underwriters in New York on February 24 in which the author discussed the several types of furnace explosions and explained why explosion doors are generally ineffective in preventing damage.

THE value of explosion doors on boiler furnaces is problematical and to the best of the writer's knowledge no manufacturer of large boilers now recommends the installation of such doors, nor installs them, except where specified by consulting engineers or purchasers, or where required by state laws.

I quote from the standards of the National Board of Fire Underwriters, Pamphlet 60-A as approved November 30, 1945, by the American Standards Association:

> "While it is feasible to build the pulverizing system strong enough to withstand any possible explosion, it is not practical to build the furnace to withstand this internal pressure. Explosion vents on furnaces are not recommended as they have not proven to be of much advantage except as a warning, because it is impossible to make them large enough to relieve any possible explosion that might occur. Actually, such doors may create a hazard and their use as vents is not recommended. A small indicator door in sight of the operator, which must be kept open when lighting off, and an explosion door in the upper part of the furnace will give warning of any hazardous condition.
>
> "Furnace walls, however, can be constructed strong enough to withstand small puffs producing a pressure of $^1/_4$ lb per sq in. It is recommended that all furnace walls be equipped with buckstays capable of withstanding a furnace pressure of 36 lb per sq ft with a deflection of the buckstays of not more than $^1/_{360}$ of the span."

There are three types of explosions which result in a material increase in furnace pressure. These may be classed as follows:

1. The bursting of a furnace or boiler tube
2. A so-called "puff" of the intensity of 2 to 6 in. pressure, usually the result of delayed ignition of a pulverized coal furnace when starting the unit from cold.
3. The explosion of gas, either natural gas or gas generated from oil or coal, deposited on hot brickwork, or hot ash, or clinker.

The first type of explosion will be relieved through the boiler passes and will not produce sufficient pressure to distort the furnace walls, and seldom enough to disturb baffles or roof tile.

Low-pressure units up to around 400 psi will produce more disturbance from a burst tube than will higher pressure units. Four-inch tubes in low-pressure boilers sometimes fail by ripping open for a considerable length, resulting in an extremely high steam flow, which will usually cause sufficient pressure in the furnace to disturb baffles and frequently lift roof tile.

Pressure produced by steam flow from a burst tube that will open small doors which are not securely latched will blow steam and hot gas from any openings in the furnace. Such steam and gas flow from furnace openings may cause injuries or fatalities, and, as has happened in many cases, set fire to pipe lagging and other combustible matter adjacent the boiler.

Securely latched doors and a tight furnace setting are the best insurance against serious injury in explosions of this kind. Damage is usually confined to the furnace tubes and perhaps adjacent tubes and baffles.

Where a tube pulls out of a tube hole, the whipping of the tube due to the reaction of the issuing steam may cause damage to superheater elements and other internal parts of the furnace. However, no explosion door will prevent this damage.

Damage by Puffs Usually Limited

The second type of explosion, usually described as a "puff," occurs in pulverized fuel furnaces sometimes when lighting off. The pressure builds up from the normal furnace pressure to 4 to 6 in. water pressure in one or two seconds, coal and flame will blow out of door openings or any openings in the furnace wall, often accompanied by a considerable amount of unburned carbon or coal. The pressure is not high enough to distort the casings or supports and will be relieved through the boiler setting. Baffles may be disturbed, but whether to any extent depends on the severity of the "puff."

Operators may be burned if standing in front of an opening, therefore, all openings should be securely latched, particularly those which open on platforms, walkways or other traveled paths. Large doors in particular must be securely latched, as the amount of flame that can be passed through a large door could well cause serious injuries to personnel.

One or two small observation doors may be left open when lighting off, but the observers must exercise great care, particularly if the ignition should be delayed or appears to be unstable.

Explosion doors are useless in these cases, for unless very light and balanced they will not open until pressure has reached the maximum, and experience fails to show that damage has been prevented by such explosion doors.

The last type of explosion, that of gas, is the most serious. In such cases great damage may be done to the furnace and fatalities may well result. If damage could be prevented by adequate explosion doors, the boiler manufacturers would be the first to recommend them. Experience has proved, however, that it is impossible to provide an adequate protection by such means.

Rapid Pressure Build-up in Gas Explosions

A gas explosion is very much like that of dynamite; the reaction is instant, and the pressure at the point of explosion builds up so rapidly that nearly the full effective pressure is exerted on the furnace walls before the gas can be moved toward the boiler passes, or toward remote explosion doors. If the center of an explosion is near the bottom of the furnace, perhaps 50 to 60 ft from the roof, and explosion doors are located in the roof, the entire mass of gas in the furnace must be put in motion by the explosion before the explosion doors will open; and before this occurs the full pressure effect is felt locally at the point adjacent the origin of the explosion. Furthermore, the inertia of the explosion door is such that considerable pressure must be built up at the door before it will open.

Natural or manufactured gas used for ignition torches, or for primary or auxiliary fuel may enter the furnace through leaky valves, or valves that have not been tightly closed. If ignition gas is not ignited properly it is likely to accumulate in sufficient quantity to be extremely hazardous.

Gas explosions may be localized in a furnace so that they will not affect any part of the furnace except the immediate area at the zone of explosion. The damaging effect, of course, will depend on the weight of gas involved.

A gas explosion in the plant of a large manufacturing company in Michigan on January 1, 1937, and fully reported by the insurance inspectors at the time, illustrated this point quite well. The cause was given as the accumulation of gas from the distillation of coal deposited on the hot refractory bottom of the ash pit. While the entire furnace was damaged, the greatest force was concentrated in the lower right-hand front corner of the furnace. The front wall at this point was blown outward about one foot or more, and the right-hand wall about a foot or more, hitting a 14-in. steel column which was bent an appreciable amount. All walls were bulged, but only the right-hand front corner of the furnace was blown open.

If explosion doors are used, obviously, they must be so placed that they will not open on a space used by operators or other personnel, nor on space occupied by stairways or platforms. To meet these limitations they usually place such doors in the roof of the furnace.

When we consider small stoker-fired furnaces where the boiler is placed above the stoker and constitutes the roof of the furnace, explosion doors must then be placed in the side or front wall, or perhaps the rear wall. Unless each door is provided with a deflector to direct the gas away from the floor or platforms, or stairways, where operators may be working, these doors are actually a hazard.

Explosions in stoker-fired furnaces are due to gas accumulation from distilled coal, or from carbon monoxide formed because of insufficient air. Such explosions may center in the rear passages of the boiler or even the breeching as well as in the furnace. In any case, the violence is such that explosion doors are of little or no value; in fact, such doors may be blown clear of the setting.

An ideal explosion door would have the minimum possible weight and the maximum possible area, and be able to withstand temperatures of 2500 F or more. Such doors cannot be placed in the lower part of the furnace as the temperature conditions would rapidly destroy them.

These requirements are modified by physical conditions as to location and area, and the result is a compromise which must be far from effective.

There are records of explosion doors located in furnace roofs that have blown completely clear of the setting, breaking the hinges and fastenings intended to restrain them; and at the same time damage to the furnaces was extensive, proving that the explosion doors were not effective in preventing such damage.

The Standards of the National Board of Fire Underwriters fully describe the precautions that must be taken in operating pulverized coal-fired furnaces. In any furnace there is no substitute for care and intelligence in operation; definite and positive rules must be set up governing starting up and operation of the furnaces. Gas furnaces require particular care. Leaky valves, or failure to shut valves when the boiler is shut down, will inevitably result in a disastrous explosion unless the furnace is thoroughly purged before attempting to light off. Interlocks should be provided; also vents between the main shut-off valve and the burners, so that when the gas to the burners is shut off any leaking gas will not go into the furnace but will be vented to the open air. Even with such protection the furnace should be thoroughly purged before starting up.

Underground Coal Gasification

A booklet dealing with underground gasification of coal as a potential source of gas for use in the synthetic production of oil has been issued by the U. S. Bureau of Mines and the Alabama Power Company, under the authorships of Milton H. Fies, manager of coal operations of the Alabama Power Company; James L. Elder, supervising engineer of the underground gasification project of the U. S. Bureau of Mines; Hugh G. Graham, also of the Bureau; and R. C. Montgomery and J. M. Jarnigan of the Alabama Power Company. The following excerpts are from an historical review of coal gasification experiments:

Historical Review

In 1868 Sir William Simons suggested the gasification of slack and waste coal in the mine. In 1888 a Russian, Professor D. I. Mendeleov, suggested that coal could be gasified in place. An American, A. G. Betts, obtained a British patent in 1909 covering a method of gasifying coal in place by means of boreholes. In 1912 Sir William Ramsey, the English scientist, suggested producing gas rather than coal by means of retorts installed underground. Lenin included underground gasification in the Russian research program in 1917, but preliminary experiments were not begun until 1930. From 1930 to 1948, many experiments were performed. The Russians have claimed that the processes have been applied on an industrial scale at several installations.

Four methods were tried with varying success:

1. *Chamber method.* The coal bed was developed by a system of parallel and cross entries, with broken coal in the cross entries forming the gasification chamber.
2. *Borehole method.* Parallel entries were connected by small holes drilled in the coal bed, with gasification effected in the holes.
3. *Stream method.* A rectangular portion of coal bed was laid out between two parallel entries connected at their extremity by a cross entry. The intention was to gasify the pillar thus formed. The Russians have reported successful operation in steeply pitching beds. The U. S. Bureau of Mines and the Alabama Power Company used a similar system in a flat bed in their first experiment at Gorgas, Ala., in 1947.
4. *Percolation method.* A number of boreholes are drilled from the surface into a flat-lying coal bed. Combustion was started at the bottom of a borehole in the center of the pattern. This method offers possibilities for gasifying coal beds lying under shallow cover and for thick beds of small area. Main advantage is that no underground work is required.

Since 1940 little information has been available regarding the Russian work. In 1948 a Belgian organization performed a large-scale experiment. In 1947 an underground gasification experiment was made in Italy on lignite, a low-rank coal. (It is understood that the Belgians are embarked on their third underground gasification experiment, involving an oxygen plant for gas enrichment.)

In the winter of 1946–1947 the U. S. Bureau of Mines and the Alabama Power Company cooperated on their initial experiment at Gorgas, Ala. At times tests were made using a blast medium of either oxygen-enriched air, oxygen-steam, and cyclic operation as in making water-gas. Results were:

1. There was no difficulty in maintaining combustion of coal underground.
2. Coal in place was gasified completely. Examination of underground residue showed that only ash and clinker remained in the combustion zone. No islands of unreacted coal or coke were found.
3. High temperature developed by the gasification brought about changes in the overlying strata that appeared favorable to the process. Roof rock became plastic, expanded and settled on the mine floor behind the reacting coke face.
4. A product gas of varying quality was produced. In essence, it appears possible that a power gas can be produced either by the use of air, air-steam, or air-enriched oxygen.

It is possible to increase quality of the gases through catalytic procedures similar to those of the Fischer-Tropsch synthesis. By using proper catalysts, reaction time and temperatures, a synthesis gas of carbon monoxide and hydrogen can be converted to one essentially of methane and having a heating value of 900 to 1000 Btu per cubic foot.

Combination Steam- and Gas-Turbine Plant

In a recent discussion before the British Institute of Fuel, R. F. Davis proposed a combined steam- and gas-turbine plant as shown in the accompanying figure. Using a conventional steam generating unit with superheater, economizer and air heater, steam would be passed through a steam turbine driving a compressor supplying compressed air to a separately fired air heater, which, in turn, would deliver air to an air turbine employed solely for generating power. By performing the compression in the steam unit the air turbine could be held to reasonable size, and problems of fouling or eroding blades would be minimized.

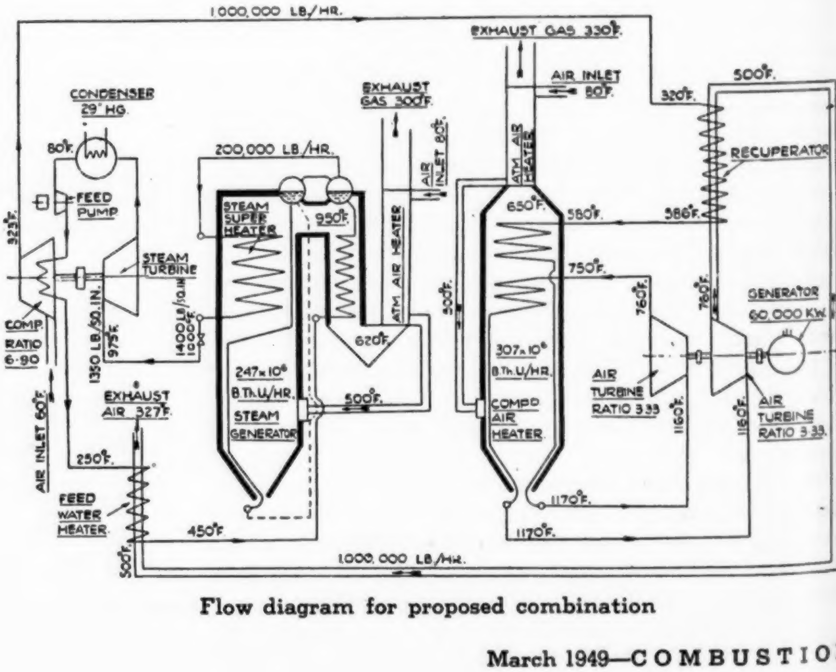
Firing the steam and air circuits separately would permit the rate of fuel input to be used for direct thermostatic control of air temperature to the turbine. It is also anticipated that all the heat of compression and a large proportion of the heat in the turbine exhaust could be retained in the system by using the condensate from the steam turbine to cool both the compressor and the exhaust from the air turbine.

Danger from overheating compressed air heater tubes during starting up could be avoided if the boiler were fired first to circulate the air. Air heater tubes would have to be of costlier material, but would be much thinner.

An overall efficiency of 35 per cent is claimed for this proposed two-stage reheat air turbine.

Still in Service with Pulverized Coal

The article on "Early Developments in Pulverized Coal Firing" in our November 1948 issue, dealing with marine applications, stated that none of the vessels fitted with pulverized coal firing in the period 1927 to 1930 is still in service with this type of firing. Our attention has lately been called to the fact that the Berwindglen, listed as having been changed to oil firing, was later converted back to coal and is now being operated with pulverized coal by the Berwind Coal Company; her boilers being fired with two B & W type B mills which replaced the Fuller-Lehigh type C mills in 1937.



Flow diagram for proposed combination

Midwest Power Conference Program

THE preliminary program has been announced for the Eleventh Annual Midwest Power Conference to be held April 18–20, at the Hotel Sherman, Chicago. It includes more than fifty technical papers and addresses on a wide range of subjects within the fields of the sponsoring engineering societies. Both central station and industrial plant problems are dealt with and considerable attention is given to water conditioning. As in former years one luncheon will be held jointly with the Chicago Section, A.S.M.E.; another with the A.I.E.E. and a third with the Western Society of Engineers. The titles and authors of papers and talks are as follows:

Monday, 10 a.m.

Address of Welcome by Prof. Ben G. Elliott, University of Wisconsin.

"Can Socialism Produce for the U. S.?" by J. W. McAfee, vice president, Assoc. of Edison Illuminating Companies.

"Electric Power Supply and National Security," by Edward Falck, National Security Resources Board.

Monday, 12:15 p.m.

Joint luncheon with A.S.M.E.—speaker to be announced later.

Monday, 2 p.m.

"Evolution of Today's Central Station Boiler," by E. M. Powell, Combustion Engineering - Superheater, Inc.

"Present Developments in Boiler Design," by F. X. Gilg, Babcock & Wilcox Co.

"Economic Factors in Transformer Application," by L. Le Vesconte, Sargent & Lundy.

"Cost of Supplying Electrical Losses," by P. H. Jeynes, Public Service Electric & Gas Co.

Monday, 3:30 p.m.

"Feedwater Treatment for the 100 Per Cent Makeup 1500-psi Boilers at Whiting, Ind.," by Glen Hull, Standard Oil Co. of Indiana.

"Feedwater Conditioning at the Steel Co. of Canada," by A. C. Elliott.

"A 10,000-cycle Network Analyzer," by W. B. Boast and J. D. Ryder, Iowa State College.

"The Anacom, The Analog Computer," by D. L. Whitehead, Westinghouse Electric Corp.

Tuesday, 9 a.m.

"Design of Small Industrial Power Plants," by Parker Moe, consulting engineer.

"What Can a Small Plant Do About Fly Ash?" by Carl E. Miller, Battelle Memorial Institute.

"Significance of the Process in Problems of Thermal and Flow Regulation," by A F. Sperry.

"Significance of Controller Dynamics in Electro-Mechanical Systems," by Prof. R. W. Jones.

Tuesday, 10:30 a.m.

"Power Supply and Requirements in the United States," by E. R. de Luccia, Federal Power Commission.

"Present Status of Atomic Power," by Dr. Norman Hilberry, Argonne National Laboratory.

Tuesday, 12:15 p.m.

Joint luncheon with A.I.E.E.—speaker, T. G. LeClair of Commonwealth Edison Co., who will discuss power supply for a large metropolitan area.

Tuesday, 2 p.m.

"Suction Intake Design for Vertical Circulating Pumps," by W. Wiltmer, Allis-Chalmers Mfg. Co.

"Recent Developments in the Design of High-Pressure, High-Temperature Steam Turbines," by C. W. Elston, General Electric Co.

"Water Treatment for the High-Pressure Plant," by Louis Wirth, Jr., The Dow Chemical Co.

"Removal of Silica from Boiler Feedwater by the Sludge-Blanket Hot-Process Softener and Exchange Methods," by J. D. Yoder, The Permutit Co.

Tuesday, 3:30 p.m.

"Resonant Grounding of Distribution Systems," by E. Herzog, Army Air Forces.

"A 33-kv Interconnected Sub-Transmission System with the Development and Operation of 4-kv Networks," by W. R. Waugh, Indianapolis Power & Light Co.

"Evaluation and Location of the Losses in a 60,000-kw Power Station," by C. Birnie, Jr., and E. F. Obert.

"Purification of Water by Compression Distillation," by E. T. Erickson.

"Preventative Maintenance Program for Small Plants," by Leland J. Mamer.

"Maintenance of Package Boilers," by F. W. Hainer, Cleaver-Brooks Co.

Tuesday, 6:45 p.m.

"All Engineers Dinner"

Wednesday, 9 a.m.

"Room Air Distribution in Year Round Air Conditioning," by G. L. Tuve, Case Inst. of Technology.

"Transmission of Heat by a Fluid Carrier," by S. R. Lewis

"Electrifying Farm Productive Equipment," by J. H. Oliver, General Electric Co.

"Providing Adequate Service on Rural Power Systems," by R. F. Quinn, General Electric Co.

"Carryover Types and the Effect of Design of Drum Internals Upon Steam Contamination," by P. B. Place, Combustion Engineering - Superheater, Inc.

"The Problem of Silica Carryover in Boiler Steam and of Turbine Blade Deposits," by Prof. F. G. Straub, University of Illinois

"Steam Contamination Experience on the American Gas & Electric Company's System," by W. L. Webb.

"High-Speed Motion Picture Study of Steam Formation Phenomena," by L. O. Gunderson and C. M. Bodach, Dearborn Chemical Co.

"Diagnosis of Carryover Problems by Proper Plant Test Procedures," by J. A. Holmes, National Aluminate Corp.

Wednesday, 10:30 a.m.

"Some Aspects of the Soil Problem in Connection with Heat Pump Buried Coil Design," by D. M. Vestal, Jr., Texas A. & M. Research Foundation.

"Controlling the Heat Pump," by F. R. Ellenberger.

"Developments in Industrial Distribution Systems," by H. B. Thacker, Westinghouse Electric Corp.

"Distribution Problems Caused by Resistance Welding Loads," by H. W Tietze, Public Service Electric and Gas Co.

Also, Symposium on Steam Contamination, continued.

Wednesday, 12:15 p.m.

Joint Luncheon with Western Society of Engineers with R. A. Stripes, Jr., of Illinois Chamber of Commerce, as speaker on "Engineers Can Influence Civic Affairs."

Wednesday, 2 p.m.

"Problems Encountered in the Treatment of Cooling Tower Water for the Prevention of Incrustation and Corrosion," by E. C. Hosbach, The Texas Co.

"Problems in the Treatment of Cooling Water in Industrial Plants," by L. D. Betz, chemical engineer.

"Two-Cycle Dual Fuel Engines," by L. D. Thompson, Fairbanks Morse & Co.

"Dual Fuel Engine Design," by George Steven, Worthington Pump & Machinery Corp.

"Dual Fuel Engine Performance and Economics," by R. L. Boyer, Cooper-Bessemer Corp.

"Television," by Fred Compton, The Detroit Edison Co.

"Promotional Sales Plans for 1949 of The Commercial Section of the Edison Electric Institute," by Harry Restofski.

"Some of the Problems Involved in the Coal Burning Gas-Turbine Locomotive," by C. K. Steins, Pennsylvania Railroad.

"Design of a Locomotive Gas-Turbine," by W. B. Tucker, Allis-Chalmers Mfg. Co.

"Water Spray Injection of an Axial-Flow Compressor," by I. T. Wetzel and B. H. Jennings, Northwestern Tech. Inst.

Wednesday, 3:30 p.m.

"Electronics in the Public Utilities Field," by W. M. Kiefer, Commonwealth Edison Co.

"Electronics in Industry," by G. M. Chute, General Electric Co.

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Bituminous Coal Facts and Figures—1948 Edition

By Bituminous Coal Institute

An attractive 148-page book entitled "Bituminous Coal Facts and Figures" has been issued by the Bituminous Coal Institute, which serves as the public relations department for the National Coal Association. Much commendable effort has been expended in making the work a complete ready-reference guide book to the coal industry, and the value of the book has been enhanced by the inclusion of effective graphs, pictograms and photographs.

The role of the coal industry is explained in terms of both historical perspective and current importance. Looking to the future, consideration is given to fuel reserves and possible effects of the adoption of such new forms of power as atomic energy and the gas turbine. Factors involved in coal distribution are analyzed, together with America's role in world coal production. Deserved attention is focussed upon the increasing significance of strip mining, and the importance of increasing mechanization of mining activities is emphasized as a factor in future productivity. Problems of marketing, as well as matters of labor relations and industry financing, also receive due consideration in the book.

Engineers in the power field will find "Bituminous Coal Facts" fascinating for its attractive formulation of statistical data relevant to the coal industry. They may also discover much of interest in the informative manner in which the facts have been presented.

Mathematics at Work

By Holbrook L. Horton

So vast is the scope of modern mathematics in range of subject matter and degree of general understandability that it is improbable that a book can be written without being classified as either too elementary or too advanced, depending upon the mathematical education and experience of the reader. Notwithstanding this fact, there are certain advantages to be gained by reading works in both realms. The so-called elementary book affords a review and a reappraisal of material which may not now be as familiar as at the time it was originally studied, while the advanced work offers the challenge of new horizons and the acquisition of new mathematical tools.

For the graduate engineer "Mathematics at Work" falls into the category of an elementary presentation of mathematical solutions applied to mechanical problems. Written by Holbrook L. Horton, Associate Editor of *Machinery*, the work encompasses arithmetic, plane and solid geometry, algebra and trigonometry. In addition to the review of basic fundamentals methods of computation are stressed. Typical problems are stated and analyzed to determine suitable methods of approach. Then appropriate formulas are presented, and their derivations are illustrated. Finally, examples are worked in complete detail.

Most of the problems are chosen from the fields of machine design and shop practice. Entire chapters are devoted to tapers, vees and arcs, forces in equilibrium, forces not in equilibrium, design factors and gear ratios. In all cases problems illustrating common mathematical principles are grouped together. A detailed explanation of the use and limitations of empirical formulas is included, and there is a chapter devoted to errors and tolerances and methods of handling them in practical computations.

The final chapter of the book contains mathematical tables aggregating 146 pages. Among those included are listings of prime numbers and smallest factors; powers, roots and reciprocals from 1 to 2000; squares and cubes from $^1/_{32}$ to 100; natural trigonometric functions; common and hyperbolic logarithms; and areas and dimensions of plane and solid figures.

There are 728 pages and the price is $6.00.

Amine Volatility and Alkalinity in Relation to Corrosion Control

By A. A. Berk and J. Nigon

Experimental efforts to minimize corrosion in central plant steam heating systems are discussed in Technical Paper 714 recently issued by the Bureau of Mines. Problems of condensate line corrosion and plugging in central plant steam heating systems requiring large amounts of makeup have been encountered in many government-operated steam plants, and the experiments described were made in an attempt to minimize such difficulties by making a scientific study of the use of amines in steam heating systems.

The three amines used in the tests were cyclohexylamine ($C_6H_{12}N$), morpholine (C_4H_9NO) and benzylamine (C_7H_9N). No active corrosion occurred at any of the testers when amines were used, nor were any unique inhibiting factors peculiar to any one amine found for any of those studied. Batch feed at 8-hour intervals appeared to be as effective as continuous treatment for providing alkaline condensates and thus preventing corrosion.

The test data were obtained in a regular operating plant under the usual constantly changing conditions. The pH, the rate of flow, the temperature, and the dissolved oxygen concentration of the condensate all probably affected the corrosion of the test coils. The rate of steam generation, the carbon dioxide content of the steam, the average pH maintained in the steam and the rate of feedwater makeup to replace blowdown and condensate losses all affected the quantity of amine required for treatment.

Chemists and engineers responsible for water treatment in central steam heating plants and those concerned with minimizing corrosion problems in such plants will find this technical paper of particular value. It is obtainable from the Superintendent of Documents, Washington, D. C.; price 25 cents.

Combustion Engines

By Arthur P. Fraas

This is a new text covering commercially important types of heat engines in which the working fluid consists of the products of combustion of hydrocarbons and air. While major attention is devoted to gasoline and diesel engines, some consideration is afforded the gas turbine.

The book is intended for the use of engineering college seniors and engineers in industry, and to satisfy such a diversity of interests an attempt has been made to relate practical considerations to basic theory. Toward this end photographs illustrating recent developments in engine testing techniques have been included, along with the extensive theoretical data. Numerous problems and pertinent technical references follow each chapter.

Following are some of the topics presented: engine types and construction, thermodynamics of engine cycles, fuel metering and injection, ignition, lubrication, cooling, supercharging, performance analysis, overhaul and maintenance, gas turbines and engine installations. To obtain a full understanding of the text, readers should be familiar with the fundamentals of chemistry, physics, thermodynamics and fluid mechanics.

There are 440 pages and the price is $5.50.

Basic Refrigeration and Air Conditioning

By Robert Henderson Emerick

Occasionally it is stimulating to read a book concerning a technical field related to though slightly removed from one's particular specialty. Power engineers may find just such satisfaction in "Basic Refrigeration and Air Conditioning," by Robert Emerick, a consulting mechanical engineer who wrote the original text as a wartime instruction manual.

Though designed primarily for those interested in careers in refrigeration and air conditioning, the work expresses basic principles in such understandable language that it should appeal to laymen and to engineers in other fields as well. An introductory chapter provides terms and definitions phrased simply without being deficient in technical accuracy. Then follow successive expositions of the properties of refrigerants, methods of refrigera-

tion, the use of spray ponds and cooling towers, the manufacture of ice, and elements of air conditioning. All of these chapters are characterized by diagrammatic and photographic illustrations of representative equipment in combination with a textual presentation that includes theoretical considerations and tabulations of important physical quantities.

One particularly valuable chapter is entitled "Calculating a Job" and presents minutely detailed steps for computing an air conditioning project. Other chapters discuss fans and ducts, marine applications and the heat pump, while there are also appended a "Trouble Shooter's Chart" and an informative bibliography.

"Basic Refrigeration and Air Conditioning" is not a rigorous treatise of forbidding intellectual stature. It does have the merit of presenting fundamental concepts and practical applications in an informal manner that commends itself to laymen, to those who are preparing for careers in refrigeration and air conditioning and to engineers whose major interests lie in other fields.

Tentative Standard on Pipe Friction

The Hydraulic Institute has issued a comprehensive "Tentative Standard on Pipe Friction." Charts and tables based on latest data have been arranged in convenient and useful form and should be of interest to engineers concerned with flow of liquids in pipes.

Professor C. P. Kittredge of Princeton University has assisted members of the Institute in preparing usable tables based on a paper delivered before the A.S.M.E. in 1944 by Professor L. F. Moody. The friction loss for water is shown in tabular form for pipe sizes from $^1/_8$ in. to 84 in. On the smaller pipe sizes, the tables are based on wrought iron or steel schedule 40 pipe, and for the larger sizes, separate tables are given for each standard size for steel and asphalt-dipped cast-iron pipe. In each table the flow in gallons per minute and cubic feet per second is shown with corresponding velocity, velocity head and friction loss per 100 ft of pipe. For computing the friction loss for liquids other than water, a series of charts is provided for pipes from $^1/_2$ in. to 12 in., showing the complete range of viscous and turbulent flow.

In addition to the friction tables, there is a very complete listing of the losses in valves and fittings. Sectional diagrams of these items are shown to indicate their internal construction. The data for bends increasers and diffusers are shown in chart form so as to include the full range of their dimensions.

The "Tentative Standard on Pipe Friction" contains a brief review of the basis of the tables, together with illustrative examples of simple and complex piping arrangements. Also included are tables on the viscosity and specific gravity of a wide range of commercial liquids and gases, as well as complete tables of dimensions of standard steel, wrought-iron and cast-iron pipes. From this information, together with charts showing the full range of friction factor, losses for any liquid or gas in

any of the commercial forms of pipe may be computed.

Since the form in which the tables are presented is unique, it has been issued as a tentative standard to provide a suitable experience period. A complete bibliography has also been included.

The price of the publication is $1.50 per copy.

Fuels Conference at Portland

A fuels conference covering the present and long-range price and supply situation of industrial fuels will be held at the Multnomah Hotel, Portland, Ore., on April 22, under the sponsorship of the Raw Materials Survey, Inc., and the Oregon Section of the American Institute of Mining and Metallurgical Engineers.

The five fuels available to northwest industry—coal, wood, electricity, gas and oil—will be discussed by specialists in each field.

Stephen Green, coal mining consultant, will cover the coal situation. An analysis of the use of wood as a fuel will be presented by Dr. Ed. G. Locke, Chief, Division of Forest Utilization, Pacific Northwest Forest & Range Experiment Station, Portland. Wesley Cook, Rate Supervisor, Portland Gas & Coke Company, will review both manufactured and natural gas. Electric power, with particular reference to off-peak electricity and energy consumption trends, will be discussed by Ivan Bloch, consulting engineer, Portland.

New Catalogs and Bulletins

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Synchronous Generators

The Elliott Co. has issued Bulletin PB 2400-1 on high-speed, Fabri-steel synchronous generators. Construction features of the machines, which may be direct-connected to diesel engines or geared to steam turbines, are illustrated in the 4-page release.

Induction Motors

A similar bulletin, PB 7000-1, has been brought out by the Elliott Co. describing its two-pole, 250–3500 hp, Fabri-steel induction motors. These motors may be of the drip-proof, splash-proof or enclosed type. Details of construction are shown in twenty-three illustrations.

Protective Coating

Apexior Number 3, a product of The Dampney Company of America, is described in Bulletin 1450, which gives pertinent information on its application to drinking and other water storage tanks, refrigerant condensers, various types of air conditioning equipment, and in the marine field. Methods of preparing surfaces and applying Apexior are explained.

Solenoid Valves

The Automatic Switch Co. has issued a 12-page condensed catalog, No. 200-R, setting forth its line of solenoid-operated valves. The following types of valves are described: safety shut-off and trip, pilot and explosion-proof. Typical applications of valves for automatic and remote control of the flow of liquids and gases are shown.

Blast Furnace Gas Burners

The Peabody Engineering Corp. has just published a four-page, two-color bulletin describing its line of blast furnace gas burners. Views of typical installations are shown, and drawings of combination blast furnace gas and auxiliary fuel burners are reproduced.

Multi-Pointer Gages

Latest developments in Bailey multi-pointer gages are described in Bulletin No. 163-B, which is now being distributed by Bailey Meter Co. Use of the diaphragm-operated unit for measurement of pressure, draft or differential is explained in detail, and some of the many standard ranges available are listed. The information includes net and shipping weights plus complete dimensions of casings.

Insulated Piping Systems

Two new booklets have been published by the Ric-wiL Co. and are of particular interest to engineers, architects and contractors who are concerned with problems of insulated piping distribution systems. "Engineering Data for Underground Steam Distribution, Section 480-2" deals with layout of piping routes, methods of estimating steam loads, sizing of pipe and steam mains, capacities of condensate-return piping, properties of steel pipe and copper tubes, and typical specifications. "Typical Engineering Drawings, Section 480-3" reproduces actual drawings used in a wide variety of insulated piping installations. These include industrial, educational, housing, hospitals, utilities, railroad and governmental projects.

Boiler Standardization

At the Twenty-Seventh Fuel Engineering Conference of Appalachian Coals, Inc., held in Detroit on March 9, Donald S. Walker, vice president of Combustion Engineering-Superheater, Inc., appraised benefits to be derived from standardized design of industrial boiler units.

The main reasons for advocating standardization are the ever increasing costs of labor and material. World War II proved that boiler plants could be built at construction rates previously felt unattainable. This was accomplished by substantially duplicating existing designs and plants. Similar advantages may be realized in peacetime.

Mr. Walker termed "engineers' whims," on the part of the manufacturer as well as the purchaser, as a cause of much unnecessary expense and pleaded for specification of certain basic items, leaving details to the boiler manufacturer. He stated that his company had standardized on industrial boilers of 250 psig, 500 psig and 700 psig, with capacities from 10,000 to 200,000 lb per hr steam output. For these units design is fixed, with outlets, for example, located where shown—and not several inches from that point. In this manner, shipment can be made in reasonably short periods at a price substantially below a tailor-made, specially designed unit.

Standardized units of this design could serve well over half of the average industrial installations within the capacity range. In new plants without existing building limitations they should be suitable for nearly all installations.

Instead of awaiting preparation of detail drawings, purchase of standardized units makes possible almost immediate issue of foundation plans, enabling an earlier start in construction. The consulting engineer, however, still has an important rôle to play, especially for industrial plants with limited engineering staffs. The small percentage spent for an informed, competent and experienced consulting engineer is more than justified in the long run.

Boiler manufacturers do not like present high prices and long deliveries. Standardized design of industrial boiler units is one way to reduce both.

Personals

Hudson R. Searing has become president of the Consolidated Edison Company of New York, succeeding **Ralph H. Tapscott** who becomes chairman of the board. Mr. Searing has been with the Company and its predecessors since 1909. Also, **Harland C. Forbes,** a vice president since 1945, has been advanced to executive vice president.

H. H. Kouns, mechanical engineer, has joined the staff of Battelle Memorial Institute where he will be engaged in research in fuels technology.

Dr. Ralph L. Nuttall has been appointed to the staff of the National Bureau of Standards where he will conduct research on the thermal conductivity of gases at elevated temperatures and pressures in the Bureau's Thermodynamics Laboratory.

T. C. Heyward, district manager of Combustion Engineering-Superheater, Inc., Charlotte, N. C., was recently installed as president of the North Carolina Society of Engineers.

C. C. Baltzly has been made manager of the station operating department of the Philadelphia Electric Company.

Edgar F. Wandt, president of the Buffalo Forge Co., has been elected president of the National Association of Fan Manufacturers.

Business Notes

The **Elgin Softener Corporation** of Elgin, Ill., and the **Illinois Water Treatment Company,** of Rockford, Ill., have joined forces by consolidating their manufacturing operations and field sales organizations; although under the new set-up each company will maintain its name, identity and personnel.

Dearborn Chemical Company, Chicago, has appointed Earl M. Converse, senior vice president and Eugene P. Fager, vice president and Industrial Department manager. The former has been associated with the Company 46 years and the latter since 1920.

Combustion Engineering-Superheater, Inc., has advanced E. Corbin Chapman to the position of chief metallurgist. He has been with the Company continuously since his graduation from Cornell University in 1928, and will continue to make his headquarters in Chattanooga, Tenn.

Edward Valves, Inc., East Chicago, Ill., announces that W. B. Osgood has become a partner in the Dunbar Engineering Company which represents Edward Valves in New York.

The Elliott Company, Jeannette, Pa., has elected Quentin Graham a vice president.

BOOKS

1—Gas Tables

By Joseph H. Keenan and Joseph Kaye

238 pages Price $5.00

Professors Joseph H. Keenan and Joseph Kaye of the Massachusetts Institute of Technology have revised their earlier book entitled "Thermodynamic Properties of Air," which was published in 1945, and have reissued it under the title of "Gas Tables." The new edition contains 64 tables covering such physical conditions and concepts as air at low pressure; products of combustion of hydrocarbon fuels with 200 and 400 per cent of theoretical air; nitrogen, oxygen, water vapor, carbon monoxide and dioxide, hydrogen and argon, respectively, at low pressures; one- and two-dimensional isentropic compressible-flow functions; Rayleigh lines; Fanno lines; one-dimensional normal-shock functions; wedge angles for downstream sonic flow; upstream and downstream Mach numbers for two-dimensional shock; and various conversion factors.

Values for the thermodynamic properties of the gases were calculated and published by Johnson, Giauque, Gordon and Kassel in the years 1933 to 1935. These results were interpolated by Heck and more recently have been reviewed by F. D. Rossini and his colleagues of the Bureau of Standards in terms of the latest values of the fundamental constants and newest spectroscopic data. It is the last-mentioned information that serves as the basis of the thermodynamic properties of this new book.

2—Air Conditioning

By Herbert and Harold Herkimer

692 pages Price $12

Intended primarily for engineers concerned with air-conditioning application, this book touches upon various phases of that industry, such as design, estimating, sales, installation, supervision, service, etc. It reviews the laws of chemistry and physics associated with air conditioning and contains chapters on such subject as heat transfer, radiant heating, elementary thermodynamics, water vapor mixtures, fans, ducts and air distribution, heating and cooling loads, dehumidification, cooling towers, drying systems, air conditioners, automatic controls. Also included are application diagrams, numerous charts and tables and problems with their solutions.

3—Standards on Coal and Coke

163 pages Price $2.00

Some 29 standard specifications and tests covering coal and coke, as issued by the A.S.T.M., are published in a special compilation of 163 pages. They are as of September, 1948, and incorporate changes made during the current year, plus new material.

Test methods and procedures pertaining to coal cover, sampling, analysis for volatile in connection with smoke ordinances, grindability, drop shatter test, tumbler test, screen analysis, size, sieve analysis, cubic foot weight, index of dustiness, and free-swelling. Specifications cover classification by rank and grade.

For coke there are methods for sampling, and tests for volume of cell space, drop shatter, tumbler, sieve analysis, and cubic foot weight. Included are a number of definitions.

An Appendix contains proposed methods which the Committee is now studying involving: test for expansion pressure of coal during coking; test for plastic properties of coal by the Davis plastometer; test for plastic properties of coal by the Gieseler plastometer; test for carbonization pressure of bituminous coal; measurement of pressures developed during carbonization by the movable wall oven; expansion properties of coal for use in by-product coke ovens; test for pressures, strains, and other properties developed during carbonization; and test for agglutinating value.

4—Engine Room Questions and Answers

By Alex Higgins

154 pages 9 × 11 Price $4.00

This is a companion book to the author's previously published volume on boiler room practice. Employing the "question-and-answer method" its principal purpose is to assist those preparing for an operator's license by acquainting them with the principles underlying the construction and operation of engine-room equipment. More than half the text is devoted to steam engines of various types, and the remainder to steam turbines, condensers, bearings and lubrication.

5—Refresher Notes

By John D. Constance

178 pages $8^3/_4 \times 11^1/_4$ Price $4.50

These notes, covering hydraulics, thermodynamics and machine design, form the basis of a tested course the author has given for several years past under the educational auspices of the Metropolitan Section A.S.M.E. Presenting the fundamental concepts, methods and applications of these subjects, the text is arranged as a review for those who have previously studied the subjects, and particularly to aid those who contemplate taking the examination for a professional engineer's license. In fact, most of the problems and their solutions are based on such past examination questions.

The book is in loose-leaf form, with paper cover, and the notes are offset.

6—Smoke

By Arnold Marsh

306 pages Price $7.00

In view of the present renewed agitation for cleaner atmospheres in many of our cities, publication of this book is timely. Its author is secretary of the Nationa Smoke Abatement Society of Great Britain and is therefore well informed on the subject.

The text is divided into two parts, the first dealing with certain fundamentals of combustion; smoke as a health problem; how it affects plant life; its destruction of property; its social aspects; and cost. Part II deals with what has been accomplished toward smoke abatement; the problem of both industrial and domestic smoke; suggested measures for its abatement and plans for progressive action. Air pollution from road vehicles, industrial fumes and dust is also discussed and a brief review is given of what has been done in various countries. The numerous illustrations have been well chosen to demonstrate the destructive action of smoke.

Those concerned directly or indirectly in smoke abatement will find a perusal of the book both interesting and helpful.

COMBUSTION PUBLISHING COMPANY, Inc., 200 Madison Avenue, New York 16, N. Y.

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